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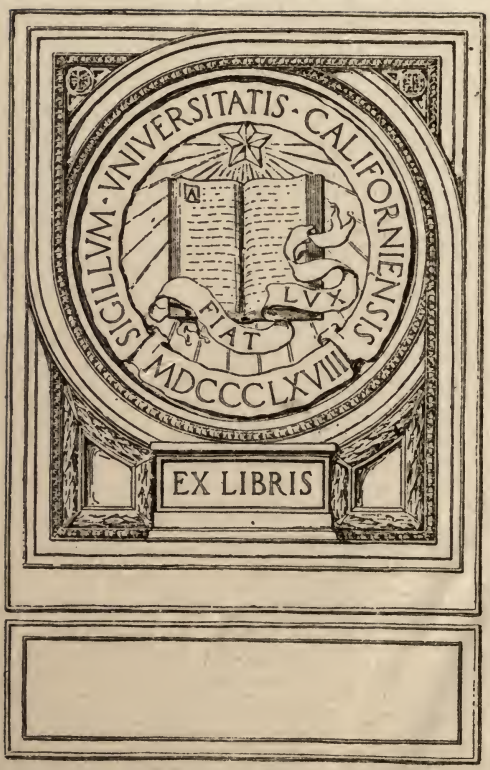
WINTER TRACK WORK

By E. R. LEWIS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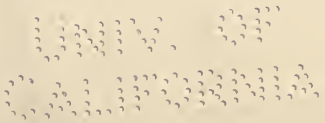
Winter Track Work



BY

E. R. LEWIS

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UNIV. OF
CALIFORNIA

To that most faithful and deserving railway employe
The American Trackman
THIS BOOK IS DEDICATED

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Railway Educational Press, Inc.,
Chicago, Illinois

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FOREWORD

Winter Track Work has been written to help the trackman.

The present is an age of progress. The trackman lives in the very heart of the storm of the world's action. He is a part of the human machine which has helped to civilize the world. The trackman is the unit of labor of that transportation system called "the railways." He is necessary to the railways. He is a part of progress. His work in this world is a real, a necessary, a vital work, a strong man's work.

As no one knows so little of a battle as the private in the ranks who sees only his individual part in it, so we, who are daily workers, realize less than onlookers, the swift changes taking place all around us; the astonishing progress in the world of transportation, and in the world outside of transportation.

The Trackman is getting the best out of this progress without knowing it. He must accept the responsibilities as well as the benefits of the betterments of modern life. He must continually strive to know his trade better, to learn and practice improved ways of doing his work. He must study ways of getting the best results out of the company's dollar.

It is hardly to be expected that the ideal conditions mentioned in this book will all be realized in any one case. Nor is the mention of ideal conditions intended to commit the author to any suggestion of insistence on their realization.

We are progressing while hardly stopping to think of it. The author has merely tried to point out this progress and to show the path along which it seems to lead.

December 15, 1916.

E. R. L.

CHAPTER I.

CLIMATE AND TRACK

All those who are interested in the care of railway track and who understand maintenance of way and structures, know that track, as it is now built and kept up, is not of the best design from the engineer's or trackman's standpoint.

Subgrade.—The subgrade is made up of the earth or rock nearest at hand during construction. It may be of hard, sharp-cornered rock, large and easily drained; it may be of slippery clay, holding water and sliding under even small loading; or it may be of sand or loam easily washed away. Even if the subgrade is good, it may be on a poor foundation. Swamp, or muskeg as it is called in the north, is a particularly bad bottom for a railway roadbed, being full of water and difficult to drain.

Ballast.—Branch and developing lines are often ballasted with earth. Most of the railway tracks of the Middle West were once so constructed. In localities where better ballast is needed, but where gravel or crushed stone is only to be had at prohibitive prices, burnt clay is in use to some extent. Cinders are used where light weight ballast is necessary.

But generally, railways are now ballasted with such gravel or crushed stone as is available from pits or quarries adjacent, or nearest to, the companies' tracks. So the ballast is not always as good as could be wished. The cross ties are fastened to the rails by spike only, each tie being separ-

ate from, and not supported by adjacent ties. Each rail is laid across a number of ties, so that a track in reality is a series of pairs of very shallow continuous girders, held to wooden cross sills by heads of spikes, which are driven only into the wood and not even bolted.

Rail Joints.—But the worst has not yet been said. The weakest parts of the track, the rail ends, are held together by splice, usually angle bars, which are sometimes hardly half as strong as the rails themselves, and which, more often than not, serve chiefly to hold the rail ends in line.

Track Structure.—Compare this track now, with a railway bridge built to hold up the same engines and the same cars. The bridge is on steel and concrete piers. The concrete piers are dug down to solid earth, solid rock, or rest on clusters of piling. The bridge is made of steel, concrete or wood, carefully placed with a view to its capacity for carrying several times its proposed load. Each rivet is tested. Each stringer or girder is carefully inspected. The whole bridge is accepted only after it is built and braced and in many ways made more than safe. It is inspected several times a year, and carefully repaired. The bridge is a scientifically designed structure, made in the best possible way, and kept in the best repair. It is on the best possible foundation and made of the best materials.

The track at its best consists of continuous girders insecurely fastened to short mudsills, laid in loose stone on almost any kind of foundation. A railway track may cost a dollar per foot; a railway bridge on the same line may cost eighty dollars per foot, yet a man to the mile is expected to maintain the track at a cost for labor and materials of $1,000 a year; while the maintenance of

bridges will cost probably twenty times that amount, mile for mile.

Track vs. Bridges.—This difference between the construction, the maintenance, and the cost of track and bridge is true in all countries and in all climates. Why? Why do we put guard rails on bridges and not on high fills? Why do we keep watchmen on bridges and not on track? Why do we spend yearly twenty times the money on a bridge that we spend on an equal length of track? Because, to a great extent, we fear the results of a bridge accident more than we fear a derailment on solid ground. Yet the best reason is that the track structure, poor as we admit it to be, is, like our system of government, the best we have yet devised.

Climatic Variations.—Now track, being built out of doors on the ground and on a foundation of earth, is subject at all times to the effects of the weather and to all its changes. We know that different parts of the world have different climates. We know that there are four distinct seasons in this country. We know there are places nearer the equator where there are only two well-defined seasons, the wet and the dry. We know that there are varying degrees of heat, cold and moisture, of rain and snow fall, of frost and drouth. All these changes of season must be foreseen and provided for by the trackman in caring for his track.

The greatest emergencies occur, not on account of the regular changes of season expected in the well known cycle of the year, but in the sudden variation from that which is expected: the unusual flood, the quick change from mild to extreme cold, the sudden intense heat, or the heavy and unusual snow fall.

There are different ways of caring for track in different

countries because of the differing conditions. But climate is the chief reason for these differences. For the weather has ever to be reckoned with—first, last and always.

Weather Changes.—The trackman must be ever ready for a change in weather, be it expected or unexpected. He must know what effect it will have on his work. He must know what to do to prevent trouble. Also, he must look ahead, act promptly and never be caught off his guard. For these reasons it is suggested that every trackman should have the latest and best news of the weather. It is almost as important for the section foreman, the roadmaster and the extra gang foreman to know what weather to expect as to know what trains to expect. With a correct schedule of trains and weather, track work may be done with the greatest confidence. Yet how few railway companies go to any great pains to inform section foremen of extra trains or of unusual storms! It is possible to do both, even in sparsely settled districts where sections are located between towns. Such a system of information would be of much service to a railway company.

The trackman is the railway company's unit of labor. To fail to give him every possible help is to maintain the road at a disadvantage. The weather report and the extra train signals are as necessary to the modern trackman as the crop report and the rural mail delivery are to the modern farmer. So little expense is connected with getting this news to the trackman that there is no excuse for failure to do so. The early adoption of such a system is strongly urged as a matter of safety involving all concerned.

Weather Signs.—Though all things that live depend so largely on climate for existence, mankind being no

exception, yet most men give little actual attention to the plainest weather signs, leaving the forecasting to a paternal government and criticizing the weather man when the daily paper quotes him incorrectly.

Few men are more vitally interested in the weather than the trackman. The farmer, whose crops and income depend so directly on weather, can sit indoors and does so, during most of the worst weather of the year. If his roofs are tight and his stock protected he has little to fear from a hard winter. The merchant loses money in unseasonable weather for he buys stock several months in advance on his judgment of what customers will want. Rain coats sell slowly in a dry season. In mild winters, heavy clothing and fuel must be carried over. The ice cream business is never best in cold weather. The banks feel these bad seasons from the same causes, for money is "not easy" unless crops and stocks move. But the farmer, the merchant and the banker do not put all their eggs into one basket. When business in one line is poor, it is usually possible to do more in some other line. The railway company has put its eggs into one basket and has given the trackman the job of watching that basket, and he must watch it for better or for worse, in all weather, by day and by night, year in and year out, come what will of calm or storm or unexpected weather. In all seasons the trackman must be on duty out of doors. The worse the weather, the more important is his patrol of track, the more necessary his watchful eye, his cool judgment, his quick action, his steady nerves, his ready hand.

The best trackman is he who gets the best results from a day's work. His head must guide the hands of his gang. Some trackmen seem always in the right place

at the right time. Their track is always in good condition, yet they work no harder than other men who are always behind. The knack of doing the right thing at the right time in the right place in the right way is what has been named "efficiency." Unless a trackman knows what the weather is going to be tomorrow, he will not be in the right place. If he is out of town and gets no weather report, he must depend on himself as a weather prophet, and any man so placed can learn something about what is to be expected of the weather by simply looking about him occasionally, at the sky, at the clouds, at the sunset, at the moon. He can learn by the feel of the air, by the way the birds fly. Most experienced trackmen are good weather prophets, yet all may not know the following signs:

Fog is almost always followed by fine weather.

Heavy dew means fair weather.

A heavy, white frost means that a storm is forming somewhere within one thousand miles.

If smoke rises straight up, settled fair weather may be expected. If it spreads out like an umbrella, storm may be expected.

Feathery, white, high-flying clouds mean fair weather.

Heavy, dark, flat-bottomed clouds usually mean rain. Low, dark, fast-flying clouds appear before a storm.

Wind, blowing even moderately, means snow or rain is falling somewhere within one thousand miles of you. Wind always blows toward a storm. If it blows from the south, expect a storm from the north. If it blows from the north, expect a storm from the south. When it gets suddenly cold a storm is starting in the south. When it turns suddenly warm, a storm is forming in the north.

When objects a long way off appear close, look out for rain.

A pink sunset means fair weather on the morrow; a dark red sunset means storm.

Weather usually changes with the moon. A ring around the moon means stormy weather.

When a storm is coming, sea birds fly toward land and swallows fly low. Sheep crowd close together and birds stop singing.

Wild geese flying north indicate the early end of the winter season.

Chief train despatchers get and watch with closest interest all prophecies and reports of the weather. They have advance information from both government and railway sources, and trains are run with these reports in mind. Thus, the only cost to the company of letting trackmen know of weather changes and extra trains is the cost of sending out notices from division headquarters. The results would seem to more than justify the small expense.

Heat and Moisture.—Heat and moisture are the weather conditions which have most to do with the trackman's troubles. Intense, steady heat makes a hot climate; moderate heat makes a mild climate; and too little heat makes a cold climate. Moisture is necessary to all life and is present everywhere on the earth. In hot climates a dearth of moisture makes a desert, while excessive moisture causes stagnant water, making thus an unhealthy climate. In cold climates much moisture means heavy snow fall and a dearth of moisture means hard and deeply-frozen ground. The wind and sun have, of course, the effect of drying up the moisture, and other

causes combine with these to make what we call climate, or weather.

Hot Climates.—Railway tracks are maintained in the warmest and driest of countries, as India, Egypt, West Africa, Persia and Central America.

In the hottest, driest climates, where rain falls only a few weeks during the year, and the railway is laid in sand, the track must be covered in ballast to the rail

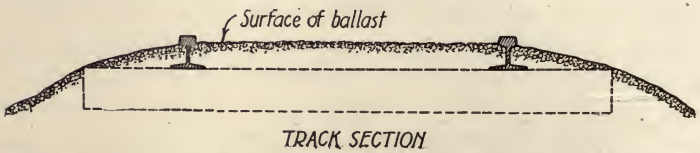


Fig. 1—Track Covered with Ballast to Rail Heads as a Protection Against the Heat of the Sun.

heads to prevent the blazing sun from heat-checking the ties and from kinking the track on account of expanding rails. Ties, spikes and tie plates are all covered. Nothing but the rail heads are seen, except at the joints where the ballast is kept scraped away just enough to clear the bolts and nuts. Even then trouble is had occasionally with kinking track. A piece of straight track in the desert looks like two shining ribbons, which stretch away into the distance, shimmering and dancing in the uncertain heat waves until they melt into one where the sky comes down to what looks like a lake, but which we know to be the track mirage at the horizon line. Such track must be carefully ballasted, the large stones at the bottom and the smallest on top to keep out the heat.

Desert countries which lie far above sea level but near the equator, are usually very dry most of the year, having only a few weeks of wet weather. But in such places there is, even in the driest seasons, a surprisingly

heavy fall of dew which cools the ground at night and causes track rails to contract quickly and excessively.

In many such localities, wood ties must be imported and are very expensive, while in others the white ant, an underground wood borer, destroys wood ties in a few months. For these reasons steel ties of various shapes have been used. Some British roads have used pressed steel ties like "U" shaped troughs turned upside down. In the driest climates these ties, when taken out of track, nearly always are full of earth or sand which clings to the under side of the tie, the earth originally having been moistened by the dew which collects at night, and then baked hard by the heat. This sand is so hard that it has to be picked out when the ties have been removed from the track.

In tropical climates, where the average ground temperature is, say 170 deg., it is astonishing how cool and damp the ground may be at from 9 to 12 in. under the surface. From this difference in heat arise queer track conditions which are confusing to the stranger.

Even when the track is covered in ballast to the rail heads, it will kink between showers in the wet season, as the sun comes out very hot and its effect is soon noticed. Then too, the hard showers wash away the fine top ballast, giving the heat a chance to expand the rails before the ballast can be replaced.

In deserts where loose sand is the only or the usual ballast, the tie tamping must all be done in the short wet season and all the labor to be had is then put onto this one job. The sand must be wet by means of a hose if ties need tamping in the dry season. Water is carried in tank cars for this purpose, but is used only in extreme cases, for water is both scarce and expensive.

Drainage too is difficult, for the little rain that falls usually comes in very heavy and sudden showers. It fills gullies, culverts and stream beds which are dry the other eleven months of the year. Many large culverts must be maintained over streams which are nearly always dry. It is hard to dam these streams or to save the water for use in the dry season because of its force when the streams are in flood and because the soil is so loose and cuts so easily.

Mild Climates.—There are climates which have no extreme seasons; where there is little difference between summer and winter; where 60 deg. is the coldest and 80 deg. the hottest temperature; where the rains are gentle and well distributed, and where a tie can be changed as well in January as in July. Such climate is scarce and the railways in such countries are unfortunately short and few.

The weather in our central and southern states, while reasonably mild, has less to recommend it. Still, frost conditions are never severe and the winter seasons are short as compared with the summer seasons. They have, however, the great problems of varying rainfall and drainage to deal with. Further north we find a climate of varying conditions in winter. Each winter season seems to have a few very cold snaps, with mild and thawing weather between. Occasionally there are exceptionally heavy snow storms which tie up the railroads, largely because of unpreparedness. The equipment is unsuited to handling snow and the companies employ few men who would know how to handle snow equipment if they had it. Sleet storms often follow the snow, and tie up telegraph communication. Thus, the greatest damage to traffic is to be expected in those localities

where extremely cold weather is the exception and where the best preparations, for that reason, are seldom made.

Wet Climates.—Excessive moisture, whether in cold, mild or hot country, is at the bottom of more track troubles than any other one condition. There are climates so wet that the railway right-of-way must be ditched and drained before any grading is started; where track work must be delayed until the rain stops, and then rushed through in the short, dry season; where weeds spring up before the grade is finished and must be mowed before track is laid; where it is impossible to keep ballast free from weeds, and hard to keep weeds mowed so as not to interfere with traffic; where borrow pits become rivers and cut away the railway grades; where dykes break from pressure of water and flood railway yards and tracks. It is easy to see, therefore, that drainage is one of the most important, if not the most important, problem of railway building and maintenance.

If roadbed and ballast are well drained, track may be maintained cheaply in almost any climate. Whereas, without good drainage it is impossible to have good track, no matter how much money is spent on it. A track, like a house, should be built on a secure foundation. The first consideration in building a house is the sewer to carry off drainage from the foundation. The next is a solid bottom on which to set the foundation. The next is a good foundation. The same things are necessary in track; first, a well drained right of way; second, a solid bed for the grade; third, a well-compacted roadbed; fourth, a well-crowned subgrade; fifth, well drained ballast—drainage—good drainage first, last and always.

Common sense should teach that a hollow-topped roadbed will hold water; that a level-topped roadbed will not shed water; and that a railway track will soon be pressed down into a level-topped roadbed by the weight of trains, thus making a hollow top to the roadbed in which water will be held, making soft track; that the only proper way to make a roadbed for any kind of travel, from a country wagon-road to a class-A railway, is to crown the roadbed so it will always stay crowned and always shed the water, instead of holding it till it soaks into the earth.

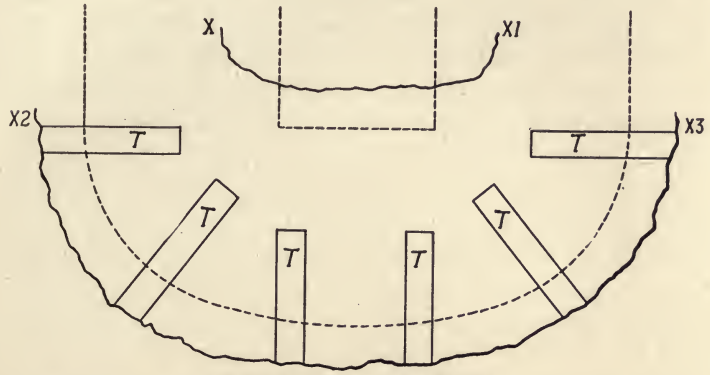
Hollow-topped roadbed results in soft track in summer, and heaving track in winter. The raising of the track gives little relief. The only real cure is to get to the bottom of the wet spot and drain it, to dig the ballast out and build up the crown of the bank. This method is, of course, hardly possible in track under traffic

Many well-crowned railway fills are made hollow-topped by widening them and carrying the shoulder above the bottom of the ballast. The damage done by hollow-topped roadbed depends largely on the kind of ground of which it is made. Water will quickly seep away through sand or other coarse filling. Clay will hold water longer than almost any other material.

Farm tile cross drains laid far enough below the ballast to drain the bottom of the hollow form the most practical remedy. Cinder covering over the tile will help, as cinders will not mix much with the clay. Cases are known where cinders on clay have sunk into the clay only an inch in twenty years under ordinary railway traffic.

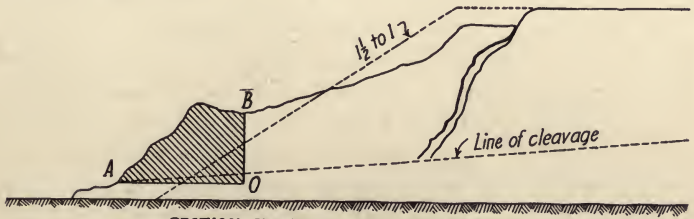
Clay in wet climates will often bear little load, for it will slide when it gets wet under pressure. It is hardly

ever possible to tell just how much weight a clay foundation on a slope will bear without sliding. If it does slide under the weight of a fill, it will not help matters to stop



PLAN OF END OF EMBANKMENT

X-X1-X2-X3 = Lines of Slide. T = Trenches in which wood is fired to bake clay to prevent further sliding.



SECTION SHOWING SLIDING EMBANKMENT

A-O-B = Longitudinal section of trench in which wood is fired to bake the clay to prevent further sliding.

Fig. 2—Method of Baking Clay to Stop Sliding of Embankment.

filling. The filling should go on until the slide finally stops or else the line should be changed. It is possible to stop clay from sliding by burning it like brick. The method is to dig ditches into the bottom of the slide, to

fill with timbers or old ties, and to set them on fire and gradually cover with the clay dug from the trenches. The burning and covering should be kept up for several weeks, until the clay is burnt hard. It will be found, then, that the water has dried out, leaving the clay cracked in all directions. These cracks will drain any water which gets into the burnt clay afterwards, and it will be found too hard and crumbling to do any more sliding.

Railway banks have been cured of sliding by thus burning the clay in trenches dug along each side at the toe of slope; and the ends of banks at bridge ends have been stopped from sliding by burning the material in trenches dug fanwise into the toe of slope, as shown in Fig. 2.

Cold Climates.—In cold countries the frost often strikes very deep, especially under track, because the ground is kept bare or nearly bare by the snowplows and trains.

In one case, a culvert top failed in mid-winter. This small culvert was under a 20-ft. railway bank. The dirt came down and nearly filled the culvert, but water from a spring above trickled through and gradually took the dirt down with it. In this way a hole some 6 ft. across was formed in the bank from bottom to top, but not until early spring did the top cave in, when it was found that the frost was 6 ft. deep. This culvert failure was under main track but it was discovered before any damage was done, by an engineer who ran a light engine over it, the tie ends on the crust of frost holding the track up.

In cold climates the frost goes out slowly in spring, with many setbacks, and alternate freezings and thawings. Frost will readily leave well drained track, but in badly drained track the water is held till it seeps away

into the ground, which must thaw thoroughly before the water can find its way out. Meanwhile the track heaves, and shims must be changed daily. Much has been said and written of the business of maintaining track. The foundation of this and of all other road work, from foot-path to railway, is drainage. Drainage means safety to the trackman.

The railway companies of this country spend millions each year to maintain track on roadbeds that never can be good, because they were poorly made to start with. Occasionally some very bad spot is dug out and made good, but most of the hollow-topped, poorly-drained roadbed will probably never be wholly remedied.

In cold climate ties can be placed and ballast worked only during six months of the year. The winter months are spent in shimming track, gaging, tightening bolts, bucking snow and picking ice.

After the tie renewals are finished and track surfaced in summer, the road is in best condition usually in the late autumn. From early winter until the frost is out in the spring, the track conditions gradually get worse. Not only is the track in prime condition during only a few weeks in autumn, at an expense equal to that necessary to keep it in good condition the year around in warmer climates; but great expense is necessary to keep the track passable during the winter and early spring months, when frost and snow, ice and flood must be fought and conquered by the track forces, which are frequently reduced to less than the economical limit.

To carry railway tracks through a winter's campaign in the cheapest and best way, dauntless leaders, experienced men, proper tools and proper equipment are needed.

CHAPTER II.

FROST.

From the trackman's point of view, and for the purposes of this book, the term "frost" is considered as weather cold enough to make ice; or freezing weather.

Effect of Frost.—As a matter of fact, weather not quite so cold as freezing will cause track to heave. The freezing point on the thermometer in common use in this country is thirty-two degrees above zero; but track will heave when the cold gets below 39.2 degrees.

If an open can, or other vessel, with a bottom 1 ft. sq., and sides 1 ft. high be filled with 1 cu. ft. of water weighing 62½ lb. at a time when the thermometer shows 39.2 deg., the water will expand and overflow when it gets colder or warmer. When the thermometer has dropped to the freezing point, 32 deg., one-twelfth of the water put in the can at 39.2 deg. will have spilled over.

If the can, instead of being open, has been covered and soldered air tight, a quick change to a colder temperature will expand the water and break the can. This breaking is due to what is called the force of expansion, which is the same force that makes track kink on hot days.

Heaving.—When the weather gets cold, this force of expansion makes the water in the ballast and roadbed quickly take up more room. It cracks the grade on the shoulder and heaves the track up. When we stop to think that this force of expansion, at the moment when water freezes, may be as great as 30,000 lb., or 15 tons to the square inch, it is not surprising that track heaves and

iron pipes split and leak when freezing. Frost, then, is at the bottom of most of the trackman's troubles in winter.

Water, when the thermometer stands at 39.2 deg. above zero, weighs nearly 62½ lb. to the cubic foot, while ice weighs less then 57½ lb. to the cubic foot. This difference in weight is, we may say, made by the overflow of water from the tin can. There is not so much of it left to freeze because it has spilled out in expanding as it got colder; or else it has bulged and broken the can, with the same result.

Every trackman who has had track alongside a lake, must have noticed in freezing weather that the ice cracks, expands and shoves hard into the shore. It has been known to push track out of line when the track was 6 ft. or more from the water's edge. In such cases, it is a good thing to cut a trench 2 ft. wide, or wider, in the ice alongside the track, say 50 feet from the center line, or as far as needed, remove the ice from the trench and slide poles slantwise under the ice to skid the lake ice up on top of the shore ice. If a 2-ft. trench is simply left open, it will sometimes close up in one night. But if the skids are so set that the lake ice crowds up on top of the shore ice, there will usually be no more trouble for the lake ice can travel 40 feet without doing any harm.

If frost gets into or behind retaining walls, or into concrete or brick walls, the heaving will crack or bulge the walls or crack the bricks, blocks or stone. Brick, concrete or stone which will take up water is called porous, because the water gets into the pores. When it freezes and expands there, it cracks the brick, concrete or stone, and they are said to "weather badly."

Heavy rains late in the fall, followed by frost, are said to make track "go into the winter badly." This is because

the rain works into the ballast newly put in or surfaced through, and freezing there, makes the track heave. Naturally, there is less trouble from heaving after a dry autumn.

Expansion Not Uniform.—If the expansion which causes track to heave were everywhere the same or nearly the same, no trackman would need to worry, because the track would be lifted the same height everywhere and would be about as smooth as in summer.

But this is not what happens. If a culvert has been filled, the track may heave badly over the new fill because it is looser than the old grade, and the ballast on each side takes more water in and expands more when it freezes. This makes a short high spot in the track.

Again, track will heave on each side of a bridge while the bridge does not heave, but becomes a low spot. Ground under crossing plank will not heave equally with ground not under cover. It is frequently a good plan to take out from between the rails all the crossing plank and to fill the spaces with snow, to prevent brake rigging and locomotive pilots from catching in heaved planking and causing damage or derailments.

Fence posts which have been pointed and driven point down are often heaved out of the ground in cold weather. If the fence post has any shoulder or bark or large knots at or near the surface of the ground, the heaving ground has something to catch on and lifts the post. Instead of pointing fence posts and driving them, in swamps or soft ground, it is better to anchor the posts by cleats nailed across the bottom ends. This will prevent the posts, if buried deep enough, from heaving and spoiling the fence.

Wooden trestles, with bottom sills resting on the ground will heave. To prevent this, the ground should

always be shoveled away from under the sill, even if a trench has to be dug and drained for the purpose.

Effect of Cold Weather on Track Structure.—Ties split very easily in frosty weather. This splitting may be prevented by boring round holes and driving the square spike in them at the quarters, leaving full spiking to be done at mid-day, or when the weather moderates.

Frost makes rail brittle and ballast hard. These conditions, and uneven surface due to heaving, are to blame for many broken rails found in winter. Shimming the most

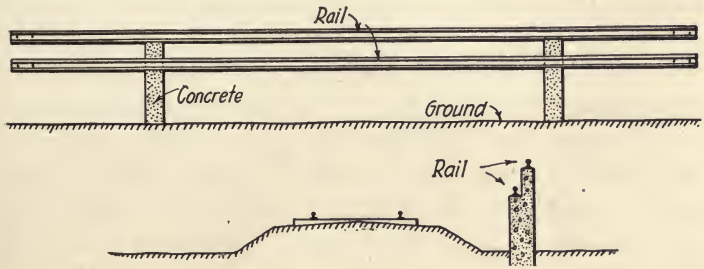


Fig. 3—Concrete Rail Rests.

uneven spots improves the track surface; but a very large percentage of broken rails will probably continue to be found in freezing weather, from these causes.

Rail Rests.—For this reason, it is advisable to have rails distributed on each section, preferably two rails to the mile of single track. Two rails and fastenings should be kept on a rail rest at each milepost so that section foremen will have them handy in case of finding broken rails in track. These rail rests may be made of ties, or of concrete as shown in Fig. 3. One object in having these rail rests always at mileposts is that everyone will know where to look for them when rail is needed, whether in case of wreck, derailment or broken rail.

Sudden Freezing.—Sudden freezing when the track is almost under water, due to melting snow and heavy rains, is sometimes disastrous, and miles of track have to be picked clear of ice when frozen under. Usually these troubles attack track which has a hard center, due to flanging for only a short distance, say 14 in., inside the track rails, the snow and ice having been left in the middle of the track until it gets so hard that it is not possible to plow it out. The center of every track should be cleared of snow after each storm, before the snow gets too hard to plow, if the track is to be maintained in the safest winter condition. Frost is much more to be feared than snow, though of course it is the combination of the two that makes track work hardest for all.

Extremely Cold Climates.—In the far north, where the cold gets so severe as 50 to 60 deg. below zero; where the ordinary thermometer is unreliable and the spirit thermometer is used; where one's breath crackles as it blows past one's ears; where opening a window causes a shower of frost to blow in because of the cold air striking the warm, moist air inside; where warm water thrown from a pail rattles to the ground outside in a thousand pieces of ice; where in December, the sun only peeps above the fir trees for a few hours each day, and is gone; where the nights are long and the stars glitter coldly; where the "northern lights come down o' nights to dance with the houseless snow;"—in these far northern climates winter is indeed a hardship for the trackman. In the crisp, dry air of the far north, the frost knows no surrender. It is one long battle from early fall until late spring. Thawing days are unknown. Snow comes early and each storm increases its depth. None melts until spring. Moccasins may be worn for six months without

getting wet once. Each wind that blows, drifts the snow, and frost prevents it from packing. Engines steam badly; gasolene cars are out of the question; train pipes freeze and track at water tanks must be watched hourly to keep the rails, flanges and centers free from ice.

Of the greatest service in such extreme cold is the steam hose. The steam hose is made of 3-ply rubber, measures from 1 in. to 1¼ in. across, inside, and is fitted with about 3 feet of gas pipe at one end, for a nozzle. The coupling is a loose, 6-sided brass nut that can be screwed to the steam dome valve. A locomotive with a line of 50 feet of steam hose coupled on to a globe valve in the steam dome, with coal well-housed and dry, with storm curtains protecting the gangway, with a good pilot plow supplied with outside flangers, set close to the pony truck and replacing the pilot, with a crew used to flanging and plowing and making way over a winter track, can do more to help itself than any number of snowplows can, unless the snow is very hard, deep and heavy.

The steam hose can be used to thaw ice from water tanks, to clear ice from the running gears, and to thaw out switch points, or rail flanges at crossings.

Size of Winter Force.—It seems a common idea that in winter the maintenance forces should be cut down, because the section men "can't do anything much in severe winter weather." There is, of course, more to do on some roads than on others, in winter. But it is no longer a question among trackmen whether the section gang should be cut down to one or two men and a foreman. The force should not be cut down too close, for the following reasons:

First, because of the necessity for looking out for the safety of the traveling public;

Second, because having enough men in all gangs saves money for the company;

Third, because good section labor is skilled labor, and skilled men cannot be hired and fired like cabmen on a city street.

As to safety: when a track heaves it goes out of surface. One rail is often higher than the other, or both may heave several inches high for a distance of only a few feet. These high spots must be shimmed. The track usually heaves in spots all over a section at the same time. Every rail in it may be up today and down tomorrow. The side motion of engine and cars may widen the gage on account of uneven elevation of the rails. Spring hangers are in danger of breaking. Crossing rail flanges get frozen full of ice which causes derailments, if not picked out. High-shimmed track is dangerous, for spikes don't reach far into the tie and bracing must be well done. This work needs the best of judgment and the closest of attention from the most experienced trackmen. Shimmed track is a continuous nightmare for men in the "know." It must be gone over by day and by night. It must be watched from fall till spring. It is hard to tell when high-shimmed, snow-covered track is spread, or braces loose. It must be left rough where it is dangerous to shim higher; and slow orders be put on and obeyed to the letter.

Winter Inspection.—When track is rough, there is danger of breaking the rail if the speed is fast and the loads are heavy. Trackmen must therefore watch carefully in winter for broken rails. There is more need of careful track walking in winter than in summer. The

weakest spot in the track is the joint. The best rail joint depends on bolts and nutlocks to keep it tight against the rail. Bolts get loose on account of weather changes, as well as other causes. It is therefore most important to keep bolts tight in winter when the rails are in most danger of breaking from frost, and through movement under trains. Most rails break at the bolt holes. There is also more danger of signal wires, telegraph and telephone wires and interlocking plants getting out of service from winter conditions than from summer conditions. There is danger of persons being hurt on icy platforms at stations. There is danger of trees, loaded with ice and snow, falling across tracks.

There is danger from gorged streams overflowing and freezing in track. There is danger from hidden switch lights, snowed over or frosted. There are a thousand emergencies in winter calling for the head and hand of the experienced trackman. There should always be enough men on the daily track inspection trip to take out a broken rail and put in a good rail. This work must be done under the protection of flags. Few main tracks now have rails that weigh less than 80 lb. to the yard. They are usually 33 ft., or 11 yds. long. They weigh 880 lb. each. A broken rail must be rolled out. The spike must be pulled on one side. The new rail must be loaded off the rail rest and taken to its place in the track, unloaded, placed and spiked. In many cases it must be cut or the track bucked back until it will fit in. Now, how many men should be in a gang to handle such a job?

Again, it takes one man at least a day in summer to inspect and tighten the bolts on five miles of single track. He must walk 10 miles besides tightening bolts, first on one side and then on the other, of the track. This is a

stiff day's work if it is done right, especially with the present-day system of putting half the nuts on one side of a joint and half on the opposite side. Also the track walker must carry a track wrench, maul, spare bolts and nuts, and nutlocks.

But in winter, storms and cold bring ice and snow and make walking slower and harder work, while the burden of heavy clothing and overshoes and a shovel to clean snow and ice from rail joints, doubles the work of bolt tightening, which should then be done by two men. There seems every reason why winter track forces should be increased, from the standpoint of "safety first."

Real Economy.—From the economy standpoint, too, a small force is extravagant. Because a railway company has escaped disaster during an unusually mild winter with a foreman and one or two men to a section, is sometimes taken as a reason for trying it again.

But economy does not always mean saving. Too much saving is poor economy in track maintenance. It costs about so much a mile each year to maintain track. If maintenance is robbed one year, it must cost more the next. Inexperienced men are of no more use on a section than in a machine shop or a bank. A section man is not a trackman until he has worked on a section for, at the very least, 12 months running, for there is a different work for each season and each month. It is cheaper for a railway company to pay three good section men a good wage the year around than to hire inexperienced extra gang men or extra section men for a few months in summer. Until those who control the hiring realize that trackmen are skilled laborers, and that to keep them the year around is economy, money will be thrown away which could easily be saved.

A record of the number of accidents to trains prevented by trackmen, and of the cost of accidents not prevented, might help to an understanding of why the trackman is so badly needed in winter.

Skilled Labor Required.—It is so often argued that unskilled labor can be used on track that a few questions to the arguer may be a help:

Can you drive a spike?

Can you tamp a tie?

Can you use an adz?

Can you flag a train?

Can you line track?

Can you tighten a bolt just tight enough and not too tight?

Can you cut a rail, or brace a shim, or do any one of the hundred things that a trackman must do?

You surely cannot unless you have had experience. But, you say, green hands do get this work done. They do not, unless the foreman teaches them or unless other trackmen, who have had experience, teach them. And all the time these men are learning, the company's property as well as passengers' lives are more or less in danger. These dangers can be stopped, without any extra cost, by getting, paying, and keeping all the year around, trackmen of brains and experience. This idea has been a long time getting started, but it has come to stay. Many companies are keeping more men in the track department in winter than they used to, and there is work now being done in winter that used to be rushed through in summer. In the next ten years, the track man will come into his own. He will be known as a skilled laborer because he can no longer be called anything else. Skilled labor calls

for steady work, and steady work it must be for those who want and should have it.

Summer vs. Winter Work.—The summer work is no more important than the winter work, nor is there any more of it outside of a few stock jobs, which are usually done by extra gangs, or by contract. The idea that a trackman can't do much in winter sounds childish to the man who knows what a track is, what it needs and how it should be maintained. If such men only were in authority, few trackmen would be discharged in winter and better track would be kept for less money than is now spent.

Take the one item of keeping bolts tight. A rail should last, say 30 years. It now lasts possibly 15 years in main track. Why? Because it gets surface bent. Why does it get surface bent? Because the ends are bent down when the trains go over. Why? Because the joints are weak. Why? Because they get loose and work up and down and don't hold the rails tight together; so the rails get bent on the ends. What would make the joints strong so they would hold the rails close and tight and keep them from getting down at the joints? Why, any sort of bolts and nuts and nutlocks or washers that could be kept tight.

Why do the bolts that we now have get loose? Oh, because the trains shake them loose. Exactly, exactly. And the bolts we now use can be kept tight up at the joints and from five to ten years or more added to the life of the rail if, summer and winter, it is made someone's particular business to do this particular work.

Rail costs $4,000 to $5,000 per mile of track, or say $25,000 to the 5-mile section. If one trackman, at $2 a day, spent one-fifth of his time tightening bolts on a section, and if he made the rail last only five years more than the fifteen years' usual life, he would save, roughly, one-

fourth of its life which is equal to one-fourth its cost and interest on the money spent. Is it worth while?

But that is not all the bolt-tightener saves. He saves, for an interval of five years, the cost of taking the rail out, sawing off the ends and putting another in its place, and the interest on the money which would have been expended for such work. He saves rough track, and wear on cars and engines, on wheels and spring hangers, and on engine frames and trucks. He saves money spent on everything that goes over the rail joint, and interest on the cost saved. Think of it! Is it any wonder that, time out of mind, trackmen have longed for the time when men who really "know track" could get the attention of the officers who spend the money for railway companies, to show them the mistake of mishandling track forces by cutting them down in winter, by hiring green hands, and by forcing the slighting of track conditions?

Farming has so changed that it is now a very different business from farming 20 years, or even 10 years ago. So with the furniture business, the grocery trade, the automobile business. Is it to be said that the railway business, the maintenance of a quarter of a million miles of track that carries the goods that make possible all other trade in this country, has not progressed? Can not railway men learn this lesson? The money question is the only thing in the way. Well, the money question is here no question, for untold millions can be saved by just keeping your bolts tight. Do you need any better argument, Mr. Trackman? If so, figure out to your boss a few other items of saving on a section, possible with experienced trackmen compared with men who don't know the business. How about tamping ties, or draining ballast or—the list is almost endless, the possible saving almost out of reckoning. These things

are known and have been known for years to trackmen, to men who think for themselves—and they are becoming known to others. The trackman is coming into his own. He will not long be idle in frosty weather.

CHAPTER III.

SNOW.

One of the first results of frost or freezing weather is snow, usually only a few flakes during the first days of early winter. These seem harmless enough, but the trackman of experience in a northern climate takes grave notice of these wintry messengers, and prepares for the long struggle. He well knows that however good his track may ride in late fall, it will be rough enough before spring and that he must stand by, day after day, through the long winter season and see it go from smooth to rough without power to prevent. He knows that these scattering snow flakes "a moment seen, then gone forever" are the forerunners of the deep snowfall, of the swirling drift of midwinter, and of the hard banks of sandy, icy snow that must be shoveled off and loosened with a pick "when the days begin to lengthen."

Characteristics of Snow.—Snow is defined as "congealed aqueous vapor," which means that snow is the frozen dampness from the clouds. Any one who has traveled fast through a heavy, damp fog will remember how wet the front of his coat has been from the tiny drops of moisture. Such dampness falling from the clouds, freezing on its way down or just as it starts to fall, into clusters of little ice needles, is snow. Each flake of snow is made up of thousands of tiny, separate needles of ice, always placed together to form six sided shapes, which are of many different patterns, as may be seen by using a magnifying glass. Each of these wee ice crystals glitters brightly in the light, making the snowflake look white like snow, instead of like

clear ice. A snowflake is not made in the same way as a hailstone. Hail is made up of rain drops, which are driven about among thunder clouds and upward into freezing air by hard-blowing, cold wind, and frozen into ice, or ice and snow, before they fall to the earth. When these upward-blowing winds are very strong, they sometimes blow many rain drops together, and they freeze, making big hailstones.

We know that snow is not so heavy as ice and that ice is not so heavy as water. Any trackman who has helped shovel snow into an engine tank when it was nearly out of water, will remember how very little water a tank full of snow seems to make. But if snow will melt into water, it will also freeze into ice if the flakes are tamped or pounded together. The more dampness there is in a cloud from which snow falls, the bigger will be the snow flakes. Large rain drops usually fall in summer showers which are short and local. It is the same with snow. Large snow flakes come in unsettled winter weather and we might call these storms "snow showers." Severe snow storms start usually with fine snow, just as severe rain storms start usually with fine rain. The air near the ground is warmer than it is a mile above the ground. The further one goes above the ground, the colder the air becomes. We read of airmen who have to dress in winter furs in summertime when flying, and who still suffer from cold when flying very high. So we often have snow from the upper cold air when the air near the ground is so warm that the snow melts into slush soon after it falls.

Even this snow that melts is bad for track, because it forms water that soaks into the ballast and under the ties to the subgrade. If the subgrade is not well drained, the water which collects stays there till it can seep away. But

if the subgrade is frozen the water will stay there till spring, freezing and thawing time and again and each time heaving the track. Such a track is said to have "gone into the winter badly." Late fall rains, coming after track has been surfaced through, and early winter snows that melt on the track will get through the ballast; and if the subgrade will hold it, the water will cause the track to heave again and again all winter long, with every freeze and thaw. This track may be down today and up tomorrow, first in one spot, then in another, and always out of surface. The only remedy is to shim and watch and shim again.

Preparedness.—Preparedness is the keynote of the snow campaign, just as it is in the case of a military campaign, except that in the snow campaign the battle is assured. It is only a question as to how severe it will be, for snow fighting is a war against a relentless foe who gives no quarter. When and where and how and with what force he will strike is never known until the storm is upon us. Even the scouting done by our weather bureau cannot give us any too much notice—at most a day or two. How long the struggle will last and whether a second storm is in reserve to strike as soon as the force of the first is spent, it is impossible to know exactly. The trackman must be prepared in all ways to take hourly advantage of any and all turns which may be to his advantage in the tide of battle. His orders must be given and obeyed promptly, for there is no time for argument in the midst of battle.

There is a tendency sometimes for those not in direct charge of track to slight the preparations for snow-handling, especially in the late fall and early winter. Engines may be scarce and therefore the testing of plows and flangers may be put off till too late. Cars may be scarce and there-

fore shims may not be distributed early enough. There is a sporting chance that next winter will be as mild as last winter, and that the expensive repairs needed to put broken rotary plows in running order may not have to be made. Power for revenue freight must be furnished first and none may be left to run snowplows after the first storm or two. Besides, it is extra work, it costs money for which no money is directly returned, and it lessens the monthly statement of earnings. These mistakes "come home to roost" later in the winter. It is the trackman's duty to call attention to these things, and to keep calling attention to them until he gets results. Undoubtedly it is not pleasant to do so, but the trackman knows the conditions better than anyone else. The despatcher from his desk can neither see the track nor know its needs. Officers cannot always judge track conditions from an occasional trip on a fast train. It is the trackman who should know, and it is the trackman who should tell, and keep telling the needs for snow fighting, till he gets the necessary attention and equipment and tools for his winter's work. Knowing this, he should start early and get well equipped before the first snow falls. He must prepare every autumn for the hardest known winter on his territory. There is no other safe way of doing. Lack of foresight in snow handling is just as fatal as in train handling. Often the mistakes in snow handling are the more far-reaching and expensive. One hard winter poorly prepared for, may cost a railway company more than has been saved during several mild winters by curtailing expenses for snow fighting necessities. Preparedness for winter track work depends on past experience with the weather conditions in any certain territory; with the kinds of tracks, yards and terminals to be protected, as well as with the equipment and tools at hand for use.

The handling of new snow is easy, but the handling of old snow is the hardest kind of work. Long-continued winter storms, when it snows and blows every day for a number of days' running, are hard to deal with. Extreme cold adds much to the trouble. Water-supplies freeze; engines do not steam well; rails break easily. Everything made of steel breaks easily in cold weather.

Troublesome Places.—There are always well-known bad spots, where snow causes severe trouble, on every northern railway division. They may be protected by snow sheds or snow fences, or they may be unprotected; but they are all well-known to the trackman. Even so, he may find storms coming from different ways in different winters. Snow collects in long, low, narrow cuts. They soon drift full and there is little room in which to push the snow back. This snow is hardly deep enough to call for a rotary snowplow, especially if the rotary is badly needed in heavy drifts elsewhere. Here is a case where the trackman needs to use good judgment—and all of his available equipment.

Advantage of Having Track on Embankments.—In places where the winters are long and severe, and the snowfall heavy, it is a good plan to build the track a foot higher than the average height of the snow in midwinter. If the snow gets 2 ft. deep, track should be built on 3-ft. fills instead of at grade. This allows for the ridge of snow, made on each side of the track by the snowplow, besides the depth of snow outside the track. If the snow on each or either side of the track is higher than the rails, snow drifts will form. If the rails are higher than the snow, any snow which blows will not stay on the track, but will blow across and drift against the first fence or brush pile it comes to. Building track on a 3-ft. fill to do away with cuts is not so expensive as one might think because the cuts

are sometimes in rock, but the fills are nearly always of earth. The extra cost, if any, of so building a road, will be made up in better maintenance conditions, which benefits increase with time at compound interest.

Snowplow and Flanger Signs.—One of the trackman's first duties in preparing for winter in the north is to set his snowplow markers or flanger signs. These markers are small signs which are set in the ground before it freezes, to show the snowplow operator the switch leads, crossing plank and cattle guards, and any other obstacles which may be covered by snow and too close to the track to let the snowplow wing pass, extended; or too high for flanger knives. Before getting to each of these signs the operator closes the wings of the plow, and raises the flangers. When putting up markers in the fall the trackman must be careful to miss no objects which need to be marked. He must look out for low piles of broken stone, gravel, cinders, sand and broken draft rigging which may be in the clear for trains but not for extended snowplow wings. If possible, in every snowy country, cattle guards should have wing fences laid so flat or so far from the track center that extended snowplow wings will not hit them.

Shims.—Stocks of shims should be distributed to the car houses or wherever else they will be handiest for the foremen. Braces for shims and special shimming spike should also be distributed. Coarse salt and rattan brooms are necessary, with, of course, snow shovels and scoops. The quality of all these tools and articles is important and should be thoroughly understood and tried out before winter begins. It is often advisable, as has been said in a former chapter, to take out the crossing plank on each side of track rails and fill the space with snow, because of danger to trains from these plank heaving. Some trackmen take

out their cattle guards; for when they are covered with snow, no livestock will be turned by them. It is customary for many roads to take switches and frogs out of the main track temporarily if they will not be needed for a number of months. This is especially handy in winter, for the company saves not only the wear and tear on the switch materials, but the cost also of keeping it free from snow and ice. Signs, of which there are too many by far on nearly every railroad in the country, should be set well back from the track to clear the snowplow wings when extended.

Handling First Snows.—One of the most important preparations for a hard winter's snow fighting is to get the first snows as far away from the track as possible. All the room will probably be needed for later snowfalls. Snow that falls between the rails gives trouble till it is out of the track and off the roadbed. To make a clear space for wheel flanges, northern roads use flangers on locomotives, or specially built cars. These flangers drop down an inch or two below and clear a space about 10 in. wide just inside each track rail. The snow in the middle of the track is not removed. If left long in the middle of the track, this snow gets hard and icy, and accumulates until it is higher than the rail—as high as truss rods and brake gear will allow. When it gets high enough and hard enough so that brake beams drag and truss rods cut into it, it will keep engines from pulling full tonnage. Snow should be plowed out after each storm. Nothing should be allowed to interfere with plowing out the center. If no plow is at hand, one should be fitted up as soon as possible and put to work. It is surprising how many railways are helpless in this respect, having snow equipment for all purposes except to handle snow below the level of the rail in the middle of the track.

Clearing Snow from Yards and Sidings.—There is an ice-plowing attachment for a center plow, called a fine-tooth comb, which will handle ice and hard snow when properly managed. In clearing snow from yards and wayside-passing tracks, spreaders or long wings are very effective and are used by many railways. If two adjacent, parallel tracks can be cleared of cars at the same time all the snow in a yard can be shoved from one track to another and off to one side of the yard. But if this has to be done often, the snow banks at the side of the yard get too old and hard and icy to move. A steam shovel of some sort, preferably a fast moving ditcher, will then have to be used to shovel the hard snow further back. This is slow work at best and the machine which will do the quickest work is cheapest. Snow is much lighter than gravel,—which steam shovels usually are built to move,—so a larger bucket can be used. The bale of the shovel or bucket generally limits the width of a shovel, but it is feasible to extend the nose. The steam ditcher is desirable because of the spud, especially in wet snow.

Drifts.—In open flat country where there is little or nothing to break the force of the winter winds, drifting snow gives the most trouble. Sand and dust drifts with the snow and fills in the low cuts sometimes faster than it can be removed.

Intensely cold weather adds trouble by freezing the locomotive water supplies solid in reservoirs and tanks. In such weather the snow in drifts becomes hard and frozen while still seeming to be almost dry. Drifts which are high on one side are especially hard to handle with a snowplow. It is dangerous to run a plow into a hard snowdrift without first shoveling the track rails clear, far enough into the drift to be sure that sand and ice will not derail the plow.

A face of snow two or three feet deep should be made. Two locomotives should be with the snowplow, one locomotive handling the plow when bucking the drifts, the other engine being ready to pull the plow and its locomotive back into clear if it sticks in the snow. Sometimes three engines are used, two on the plow and one to pull them out when fast in the snowdrift. A great deal of this bucking of snowdrifts must be done on account of narrow cuts—because there is no room to spread or throw out the snow. The ideal remedy for such conditions is to widen the cuts, flatten the slopes and deepen the ditches so that the track will look as if on a 3-ft. fill instead of down in the bottom of a narrow cut. This will give room for snow, which will then often be whipped out of the wide, flat-sloped cut by the wind instead of drifting the cut full.

Locomotive Water Supply.—The failure of locomotive water supplies is a serious matter. The only remedy in extreme cases is to haul water in tank cars from places where it has not frozen. At times the water in these cars will freeze unless a little steam is kept running into each tank.

A locomotive should be equipped with a globe valve on the steam dome for use with a steam hose. Enginemen and snowplow operators should be kept supplied with wood alcohol for clearing the glass in windows and port holes from steam, ice and snow. Weather strips on engine-cab and snowplow windows help to keep out the snow and wind. A housing of dressed and matched lumber over the coal in engine tanks is a necessity for good work in snowy weather. Tarpaulins are extensively used with good results in gangways of locomotives. Engineers not experienced in snow handling will usually, when stalled in snow, skid the drivers, burn the rail and get the track full of

water and ice trying in vain to start after stalling. If instead of doing this, the engineer will back up a few feet, get the rails cleared of snow with the scoop, and sand them for a rail length ahead of the pilot, he will stand a good chance of being able to again start his train If he stalls again, repeating the process for two or more rail lengths may help him out of the trouble. Trying to start from a standstill in deep snow is equal to trying to jump by lifting on one's boot straps; yet it is too often the first thing done when a locomotive is stopped by snow.

Snow at Terminals.—Much of the trouble of handling snow about roundhouses and locomotive terminals is because of the number of spur tracks to be cleaned; because

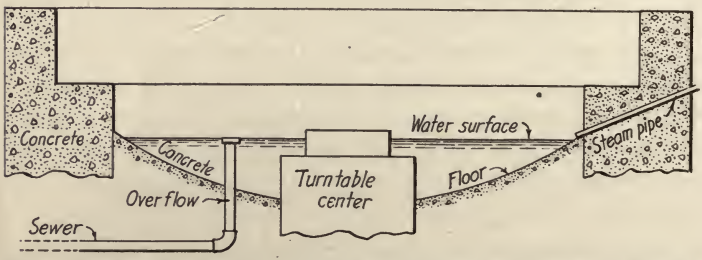


Fig. 4—Diagram of a Section Through Concrete Turntable Pit, Showing Heat Pipe and Overflow Pipe.

of the space between the roundhouse and turntable having to be shoveled and the snow loaded on cars; and because of ice forming about the roundhouse doors so as to prevent them from being opened.

A simple, yet apparently little-known arrangement will do away with most of this trouble and pay for itself in money saved in a short time. The turntable pit should be deepened, if necessary, and a water-tight concrete floor laid in it. The inlet of the turntable pit sewer should be ex-

tended straight up into the air, with a suitable bend, as high as the turntable center or within an inch or two of that level. The pit should then be flooded with hot water to the top of this overflow pipe. This water can be kept hot with exhaust steam led through a pipe from the roundhouse. Instead of shoveling the snow out of the turntable pit onto cars, all the snow about the pit and house can now be shoveled into the hot water in the pit, to melt and run off through the sewer.

In case the turntable pit is in clay, it may hold water without a concrete lining. The only expense then will be to put in the sewer overflow and the steam pipe. One laborer will then keep the snow and ice away from the whole plant, getting the same result as the snow train with its crew of engine and trainmen and shovelers.

CHAPTER IV.

SHIMS AND SHIMMING.

Until recently, the work which was done in winter by the trackmen of northern railways was restricted almost entirely to that necessary to keep lines open for traffic. Little or no repairs were made to track or roadway. Maintenance forces were cut down almost to the minimum necessary to clear switches of snow, shim the rails and patrol tracks. While these conditions are still unchanged on many roads, there is a growing tendency to extend the winter program, and so to keep more of the men in track gangs permanently employed.

While shims are provided and shimming paid for, the subject seems to have attracted less attention than its importance merits. Few books on railway maintenance make any mention of shims. There is no standard shim and no standard way of applying shims. Each railway company has gone its own way in shimming, relying on the judgment of its maintenance officers as to what was the best way to meet the needs of its special territory.

Shims.—Track shims are small pieces of hardwood boards of varying thicknesses placed on ties and under the rail to raise the height of rail in low spots to correspond with the heights of rail in high spots which occur on account of frost heaving the track unevenly. Shimming is of only temporary benefit; the money spent on it brings no return. Track shimmed in autumn is in worse condition in spring than track that has not

needed shims. Shims put in must be removed at considerable cost.

Certainly the conditions under which shims are used are different in different climates and on different railways. Tracks in the middle states generally are high-speed tracks in fairly good ballast maintained under moderate weather conditions. These tracks seldom heave very badly and they need few heavy shims.

But the number of shims used in tracks not so well favored is astonishing. On account of the high speeds which are required in winter as well as in summer, any small unevenness in track is a discomfort to passengers. Therefore, many hundreds of thin shims per mile are used. Nearly all companies have branches, spurs and sidings laid with lighter rail and less ballast than the main line tracks. These branch lines need heavier shims, more braces, and fewer thin shims. Lines farther north use very few thin shims. The heavier shims used must be of durable wood, for they are often in the track for three or four, or even five months. During this time, the shims may be snowed over during all except the last few weeks. Therefore, they must be put solidly in place and as solidly braced.

Shimming.—While the differences in climate and other conditions no doubt account for some of the differences in methods of shimming on different railways, still there is evidence in some cases of lack of forethought in this important matter.

Whatever work a man has to do, it is well for him to try to think it out for himself; to know not only what he is going to do, but why it must be done, how it can best be done, and what will be the results after it is done. The trackman often must act first and think afterward, so far as improvements are concerned.

But he should *think*—be it before or after; and he should think independently and form his own conclusions. This done, it is well to ask advice and find out by talking it over with others, who should know, whether he is right or wrong in his conclusions, and why.

From cause to effect is the usual way to get at it. Track must be shimmed—why? Because it heaves unevenly in spots. Track heaves—why? Because water in ballast and roadbed expands in freezing and lifts the track. What is the most lasting cure for heaving track? Perfect drainage and good ballast. Where perfect drainage is not possible shims must be used until conditions can be changed. It will be found that the differences in drainage correspond closely with the uneven spots in heaved track. High spots will be found near bridge ends because, while the bridge does not heave, the frost lifts the track at each bridge approach. Uneven spots are found also at cattle guards, at grade crossings, over newly-placed culverts and pipes, and over steam and other conduits which are warm enough to dry the ground above them. Track on high trestles will go suddenly and seriously out of surface from the heaving of the ground under a bottom sill-end resting on the ground. Too much care cannot be taken in keeping bridge sills clear of the earth, and in arranging all bridge and culvert foundations so that the action of frost will not affect them.

To place shims under a rail, the rail must first be raised by drawing, or partly drawing, the track spike. The shim is then slipped under the rail and fastened with track spike or crossing spike, according to its dimensions and style. The rail is then respiked, and sometimes braced, to keep it from spreading. With a shim under the rail, the track spikes do not extend so far into the

tie as without the shim. The rail also is off the tie and not so solidly bedded as before. It is easily seen that careful work is needed in shimming and that safety must be the first consideration. If only thin shims are needed, it may not be necessary to brace the rail to keep it from rolling, spreading or turning over. But tie plugs should be driven in old spike holes before spikes are re-driven. Otherwise, special long frost-spike should be used.

Quality of Shims.—It must be remembered that the rail probably cannot be let down on the tie after it is shimmed until the frost has gone entirely out of the ground in the spring. The shim must be of good enough wood to stand the moving and chafing of the rail on top, and against the stationary tieplate or tie, under it. Often it is necessary to take out thin shims and put in thicker ones in mid-winter, because a spot which has heaved in early winter will heave higher the second time, when more moisture gets into the ballast. Track often heaves out of level, one rail rising higher than the opposite rail, which condition causes passing cars to swerve from side to side violently. This side motion is particularly hard on shimmed rails which are in danger of going out of gage from the effects of these frequent blows from wheel flanges. Again, if too much shimming is done in early winter, there is danger that most of the shims must be replaced later with thicker shims again and again ,until by spring the track is up too high to be safe.

Spike Killing.—It is hard to avoid spike-killing the ties when shims are changed. A rail on a curve may be spiked to one end of a tie with three spikes. A thin shim is put in by drawing the inside spike and slipping the shim under the rail base. The inside spike hole is plugged and a spike driven in the fourth hole beside it.

Later in winter, a thicker shim is needed. All the spikes are drawn and the holes plugged. The three spikes are then redriven and a brace is placed on the tie outside and with one end against the web of the rail. This brace is spiked to the tie with three spikes, two near the rail seat and one at the outer end of the brace. There have now been ten spike holes made in the tie end. Frequently a third shim is needed before spring. This shim is a piece of oak plank about 18 in. long. It is put under the rail and spiked to the tie with four crossing spike. Then the track spikes are redriven through the shim and the tie. These are especially long track spike. There are now 17 holes in the tie end. When the frost begins to go out in the spring, the 18 in. oak shim is too high. It is taken out and replaced by a thinner shim, and three more holes are made in the tie end. When this shim is removed and the rail finally rests on the tie end, there are 20 plugged spike holes in the tie end in addition to the three holes in which the spikes rest, 23 spike holes in all! Yet engineers talk of mechanical wear, and calculate the percentages of ties which decay in track. In many instances, these spike holes are not all plugged and decay starts in such places most easily. If the tie is treated, it is likely to be more quickly spoiled than the untreated tie, and at a greater loss. For the treated tie is probably made of timber not good enough to be used untreated; and the untreated fiber of the untreated tie, around the spike holes, will resist spike-killing and decay longer than the untreated fiber of the treated tie. Trackmen should make it a rule never to allow a spike to be driven in a tie if it can be avoided. The idea that a spike hole with a tie plug in it is as good as no hole at all, is altogether too widespread among trackmen.

That such an idea is wrong is not hard to see. When a cut spike is driven in a tie it breaks the wood on each side from the top to the bottom of the hole. The tie plug never exactly fits the hole and it never mends the break in the wood of the tie; so the tie never is as good as new. These spike holes go almost through the tie. It takes only a very few of them to make a tie break under the rail bearing. This break comes gradually and the tie often rots to some extent while breaking. When removed from the track, it is often said to be on account of decay, instead of wear which is the true reason of failure. There is so much expense connected with the use of shims that they should be put in only as a last resort and when it is clearly to be seen that the traffic conditions demand them.

Taking Out Shims.—In high-speed track, heaved rail in frosty weather is dangerous. The blows struck by wheels moving rapidly over rough track are very heavy, and the faster the speed, the heavier the blows. Rail breaks easily in winter and a rail bent upward by frost under the track, may go to pieces under traffic if not shimmed. A large percentage of rails broken in northern railway tracks are broken during the spring months when the frost is going out, and the spring rains soften the roadbed. Then it is that trackmen must work as quickly as possible to change shims and finally to get them all out of the track and let the rails settle on their old beds. Track which has heaved during the winter usually will settle lower than its original level when the frost goes out in the spring. This leaves the track which has been shimmed, too high even after the shims have been removed. Therefore, the heaved parts of the track should be put in surface as the shims are taken out. Otherwise

it will be quite uneven until these frost slacks are picked up.

Shimming Requires Good Judgment.—Shimming is so largely a matter of judgment on the part of the trackman that it is not possible to lay down any hard and fast rules to fit even any one certain set of conditions. There is no work required of a trackman where good judgment plays a larger part than in caring for track in winter. There are no two miles of track which "act" exactly the same. Long acquaintance with a section of track is most necessary to the trackman who would get the best results in a winter season. Any piece of track will suffer from frequent changes of officers or foremen. But if a change of foremen must be made, unless the case is very urgent, it is poor business to make the change in winter. If the change must be made in mid-season it is preferable to make it in the busy summer season, rather than in winter, with track on shims. Shimming and its results are so directly dependent on a foreman thoroughly acquainted with every foot of the track by long residence and large experience in that particular territory, and the results of improper shimming are so dangerous, that it is perhaps not out of place to sound a note of warning even to those who may be acquainted with the particular details above mentioned.

Points to Remember.—Remember that in a climate where freezing weather occurs, no track rides quite as well in winter as in summer. Frost has its effect on the best ballasted track, and perfect drainage is as unattainable as any other worldly perfection.

Remember that the greater the train speed, the greater the shock of any inequality in track surface.

Remember that high-shimmed track is more or less

dangerous. This element of danger exists, no matter how well the shimming is done. Braces may be easily displaced by anything dragging outside the running rail. If shims are placed crosswise of the rail, anything dragging between the rails may catch and displace them. In snowy weather, shims and braces may be torn out and their absence not detected, even by a careful track walker.

The most careful trackman is excusable for not seeing that a track is slightly out of gage when he can see only the rail heads above the snow.

Remember that track in winter may ride badly from other causes than heaving. With hard snow or ice in the springs and other parts, car trucks often cause a car to ride almost as if it had no springs. A car or engine axle that is loose in the boxings will get a side motion which gives the impression of track out of surface. Such cars and engines are very hard on line and gage of track, and should be taken to the shop for repairs as early as possible.

Remember that trackmen usually know their sections and their track better than anyone else. If the foremen and officers of the track department agree in recommending slow orders, it is safest to issue the orders first and investigate later; especially if the orders are on account of heaved track. In severe winter climates, consider slower train speeds for winter than for summer. In making a slow winter schedule, consider limiting the maximum speed over each mile of track rather than the length of time allowed between stops.

Enginemen should report rough track for the benefit of trackmen.

Roadmasters should ride the locomotives in winter.

Orders should not be issued to shim until the condi-

tions are thoroughly investigated. Moderately rough track without shims in winter is usually safer than smooth track on high shims. The places where shims have to be used should be paint-marked and plans made to drain the roadbed, and renew the ballast, if necessary, in order to do away with shims in after years.

Design and Manufacture of Shims.—Some railway companies buy their shims from contractors. Others

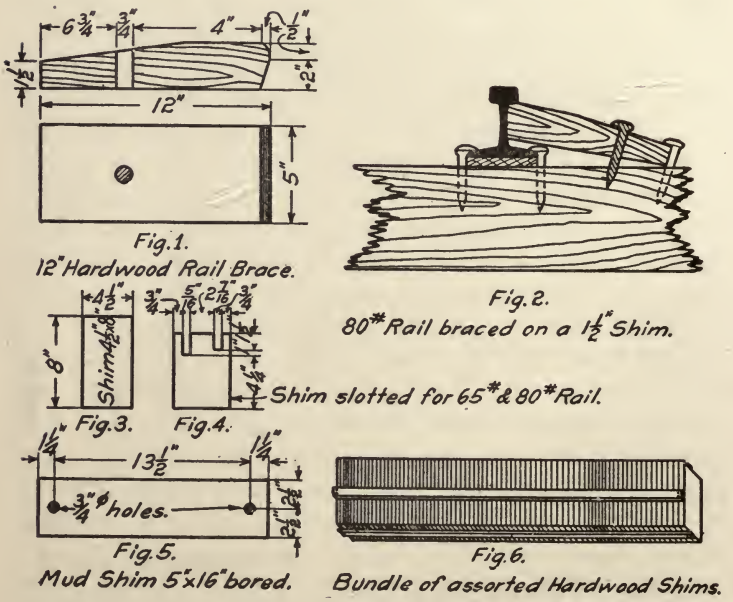


Fig. 5—Shims and Braces.

have their shims made in their own shops. Company-made shims are usually better in material, if not in workmanship.

Shims are of different sizes and of several styles.

Every shim should be long enough and wide enough to give the rail as much bearing as it had on the tie on which the shim is set. To raise the rail onto a shim which is smaller than the space occupied by the rail across the tie, is to multiply danger and invite disaster.

It is important to keep from spike-killing the ties in all maintenance work. Shimming is very hard on ties and any scheme which will lessen the number of spike holes is a money-saver for the company.

The best shim is as wide as the rail base and as long as the width of face of the tie it rests on. It is less likely to be displaced than other styles. It is more easily and quickly placed. There are no holes bored in it and no danger of splitting it with spike. The tie needs no adzing. Fewer spike holes are made in the tie than with other shims. Good, clear machine-made shims of this kind, of red oak, elm, maple or beech should wear for two winters. They should be seasoned in the bundle to prevent warping. They are usually made into bundles of 75 to 120 pieces, pressed together and fastened with four small strips of hardwood which are nailed to the end shims as shown in Figure 5.

Methods of Shimming.—To prevent these shims from working out lengthwise of the track, off the tie and into the spaces between ties, a small wire nail may be toe-nailed into the tie through the edge of the shim after placing. Slotted shims need not be toe-nailed for the slots fit around the spike and hold the shims securely in place. Shims are set on top of the tie plates. When they are under the outside rails of curves, the outside spike are braced by nailing blocks of wood flat on the tie outside the rail with a notched edge snug against the rail base and around the exposed neck of the spike. These

brace blocks are often held against the rail by means of two second-hand track spike driven in the tie back of the blocks, with heads hooking over the block. Thin shims are placed by starting the spike only just enough to slip the shim under the rail.

To shim a sag between heaved spots or to shim a run-off from one heaved spot, start the spike all along just enough to slip in the middle shim, and bring the rail to proper surface, if necessary, by tapping the spike in the ties each side of the middle shim. When the rail has thus been put in good surface, select shims for the intermediate ties just thick enough to go under the rail without bulging it up, drive them all home and tap down all the spike solidly.

Wide Shims.—A decided economy in the use of a shim of the same width as the rail base is in the fewer number of spike holes necessary. Unless a brace is needed, the shim of the same width as the rail base will go into place without seriously disturbing the two or three spike already in the tie. Shims 11 to 12 in. long are sometimes used in all thicknesses. They are provided with ½ in. round holes gaged to fit the rail base the same as are the tie plates, so that the spike that holds the rail also holds the shim. This shim is placed lengthwise of the tie. Machine-made shims that are slotted for the track spike are cut with veneer knives and machine-slotted. They are more expensive than the unslotted kinds. (See Figure 5.) These shims may be slotted for two to four track spike. Shims are also cut with shingle knives or sawed with machine saws. If shims are bought from contractors specifications should be thorough. Inspections are best made at the factory so that rejected stock need not be loaded.

Bad Practice.—Leaving shims cornerwise under the rail should not be allowed, because not enough bearing is provided for the rail. Hard snow will get between the tie and rail at the edge of the shim, and freezing there, may cause the shim to slip. Shims are usually bought in carload lots and it pays to have them inspected at the saw before they are put in the bundle. The thicknesses of shims should be specified. Assorted sizes in each bundle are most suitable. Section foremen on a division should be instructed to keep count of the number of shims of each thickness used during a winter so that the most useful selection for a bundle can be made.

It is important to have a winter stock on hand at the car houses in the late fall. Shims in the storehouse or on the road, are of no use to a trackman. When he needs them, he needs them right on the job where he can break a bundle any hour of the day.

Supervision by Roadmaster.—There is no track work which should receive more careful supervision from a roadmaster than track shimming. Some foremen have the fault of over-shimming. It is harder to break a man of over-shimming than of lifting out track unnecessarily, for it is easier to shim than to lift it on ballast. Both faults are inexcusable. Other foremen are so careful to make the shimming safe that they destroy many ties by driving too many spike to hold both braces and shims. Most foremen are slow in getting all shims out in spring after the frost is all gone, for they are then crowded with the work of picking up slacks in track and often have too few men to make rapid progress. Some men will even have shims in track until they surface through in summer. This "surfacing through" is made a too frequent excuse for putting off this and that which should

be done, on track. It is best to teach men to forget the term "surfacing through." Each job on a track section should be given its proper attention at the right time. One of the first things to do in spring is to remove shims and pick up frost slacks, and it should be attended to in advance of the spring cleaning if weather conditions permit.

The science of shimming, (always given proper tools and shims) is to shim as little as possible, as much as is absolutely necessary, starting as late as allowable in winter, using as few spike as safety permits and taking care to mark shimmed track for future drainage.

The gage of shimmed track should be closely watched at all times, and the way to watch it is to put the track gage on it as often as seems to be necessary.

CHAPTER V.

WINTER TRACK FORCE, TOOLS AND SUPPLIES.

From various sources are heard expressions from time to time to the effect that the railways of America are not economically maintained. It is noteworthy that these criticisms come usually from men who know the least about the real work of keeping tracks in good order. There is no one to whom a business seems so easy and so simple as to the man who has never tried it and who knows nothing at all about it.

Anyone watching a game which he does not understand, always thinks it dull and easy to play. There are also critics of railway maintenance who have some insight into how it should be done. They have studied the job, and they have seen it done,—but have never really tried it themselves. They are supposed to be experts. An expert has been said to be a man who makes a living by telling other men how to do things that he cannot do himself. There are many such experts in and out of the railway business.

A certain legislator once violently opposed an appropriation which was asked for a government railway because a part of the money asked for was to be spent to pay more wages to trackmen. In his speech against the bill, he raised the question of the need of track gangs on government railways. "I travel up and down this railway at least six times a year," he said. "I always see these gangs, sometimes few and sometimes many men in a gang. What are they doing, I ask you? You all ride over these tracks. You all see these men we

are asked to vote money to pay. Do they work? No, sir, they do not work! I have watched them many times. I have seen, and so you will see, fellow legislators, if you will but look from a side window of the car you sit in, as the train passes, these idle government employes, leaning on their shovels or sitting along the track, just waiting, never working! I am against voting more money to pay idle men for watching trains go by."

If this legislator had looked from the end instead of the side window of the car he might have seen the workmen start in after his train had passed.

But all criticism is by no means so thoughtless as this, nor so far fetched as some expert advice offered to practical trackmen. A man does not always have to have experience to see the weak spots in a way of doing any certain work. There are some rules which are as good for the butcher as for the baker. There are some ways of handling work which are as good for a railway company as for an army or a factory or a farm. All these institutions hire labor. All must have discipline. All must have bosses and laborers.

Man lives by comparison. One man earns one dollar in one day. If every man earned a dollar a day, there would be no very rich men. But other men earn more. They compare their earnings with the earnings of their neighbors. They hunt better ways of doing things, they try to get better results. They measure their lives by the lives of others. They say, "I do as much in one day as my neighbor does in two. Therefore I make twice as much and I am worth two such men." When a man has many men working for him, he tries to find out how much he can get done by each man. He must

study the work they do and the way they do it, to find out if he can lessen the work by doing it some easier way so as to get more done in a day. He must compare men and methods and results. All work in life is comparative.

Now, the trouble with track work, which is pointed out by critics, is that we do not so compare it. It is said that the maintenance forces of railways are the poorest workmen hired, because their work is not compared with that of their fellow workmen, who perform the same duties, to find out who is doing it in the best way. There is no standard of work. Instead of finding out just how to stand, and how few motions are needed to drive a spike home, and in how short a time it can be done, we just keep going along, driving spike "by the day," without comparing the methods or results with anyone's else spike driving to find out whose work counts for most in a day. It is said that no man would run his own business as a railway company maintains its tracks. The farmer gets more work out of his hired men. The factory owner keeps better informed about the factory workers. The general has his army better drilled. There is surely something in these criticisms, and criticism is good for any man or for any class of men.

Experienced Men Required.—In order to compare one trackman's work with another's, there must be standards for comparison. If two men are given the same kind of work for ten hours, it is possible to find out which man has done more or better work. If one gang of men works over five miles of main track for a year, and over fifty switches for another year, and works just as hard and just as many hours on each job, it is fair

to suppose that the two jobs are equal, or that the maintenance of fifty switches equals the maintenance of five miles of main track; or that ten switches equal one mile of main track. But it takes a whole year to find this out because track work differs every month in the year. To learn to do all this work, a trackman should be hired the year round, if he is to be a good trackman. A laborer is not a trackman until he has worked at the trade for twelve months running because weather conditions make his work different each month. One does not need to be a trackman to understand that experienced men are better than green hands. Then why not hire trackmen the year round, making them permanent employees? There is a difference in men. They may be strong or weak, healthy or ill, handy with tools or clumsy, stupid or quick to learn, good tempered or bad tempered. It is fair to suppose that the best results are obtainable with good men who are satisfied to stay the year round.

Permanent Employment.—There are several reasons why trackmen have not been kept the year round. Most of the track work has been done in summer. Expenses are cut down in winter by reducing forces. Money is not easily gettable till after the end of the financial year in June. In the north, the winter days are short, the weather is bad, the tracks are covered with snow, and men cannot work well when wrapped in heavy clothing. Tracks must be swept clear of snow; it is hard to run hand or push cars, and tools are easily lost in snow. The men who fill the extra gangs in summer go to their foreign homes in winter or get other work in the cities. They have no permanent interest in the work they do nor the sections they work on nor the railway

companies who hire them. Their only object in working at all is to get in a day's time for a day's pay, because they cannot hope for a steady job at railway maintenance. But logging operations in these same climates are carried on very largely in winter. Men who work on the railway in summer often work at logging in winter. There seems to be no difficulty in felling and hauling timber, making ties and posts and banking logs in the snow. Being obliged to cut timber in winter, when the sap is down and when icy roads and frozen swamps permit of hauling big loads to the streams or railways, a way has been found by logging concerns to make winter work practicable in the lumber industry, and of late years a way is being found to do a good deal of winter work in railway maintenance for the following reasons:

Labor is often more plentiful and cheaper in winter than in summer. In a limited labor market this advantage in winter work is very marked. Some maintenance work is more easily done in winter than in summer. It is less dangerous to burn old ties. It is the best time to clear fence rows of brush and trees. It is the best time to repair fence wires and to mow weeds in swamps. Many swamps can only be fenced in winter. It is best to have permanent maintenance forces. If there is not too much snow, winter is the best time to relay rails. There has been much discussion on this last point. Those who have tried it have lost the fear of "something new." They know that the moving of joint ties is expensive. They know it results in disturbing ballast and thus making bad track at the rail joints, the weakest spots in track. When track is laid in winter without moving joint ties, as it must be, the rails may be fitted with anticreepers as it

is laid. It must be remembered that the chief difficulty with rail anchors is on account of contact with frozen ballast, and this can best be avoided by putting the anchors in place when the rail is laid. If the ballast is trimmed to a surface easily drained it will be at least an inch below the bottom of the rail. The lug of the rail anchor, which is pressed against the tie to resist creeping, is about two inches deep. It should not extend lower than that. When the anchor is put on, the ballast must not be tamped about it. The best way is to scoop the ballast clear of the anchor entirely or to refill the depression by throwing the ballast loosely about the anchor. The reason for needing, say two extra anchors per rail when not moving joint ties is that the joints are not always suspended between two ties and the spike slots in the angle bars therefore may come over the ballast between the ties, and spike cannot be driven in these slots to hold the track from creeping. But all these joints do not come in the wrong places. As a matter of fact from 40 to 60 per cent of the new joints will come in such position that the slots can be used, as before. If the rail anchors are properly put on, no more than two or three extra anchors per rail length will be needed in well-ballasted track because of not moving joint ties. The track will be on evenly solid ballast throughout the rail length, and a better riding track results than when moving joint ties. Money also is saved by not moving the ties, which costs nearly as much as relaying the rail.

Experience is proving that relaying rails in winter is not only possible, but desirable from many points of view. Ballast cannot be disturbed and all ties are therefore left in their original beds. Not only is the extra

maintenance due to disturbing the ballast avoided, but the tie lasts longer when it is not moved, and it does not get blows from mauls which it gets when shifted to come under new joints.

The gaging of track is a job that can be done to the best advantage in winter.

It seems that railway companies have followed a custom in summer work. They have got used to the summer extra gang, the bunk and boarding cars, the rush of poorly-done summer work. It remains for the trackman to change this custom, to prove that the present order of doing this work is not the best, and to show what improvements will do for maintenance of way. In the north there probably will always be more work done in summer than in winter. But the winter track force will in all probability be increased within the next few years on most roads. A good deal of the work now done in summer can be done in winter to better advantage. If it is done by the permanent employes, it will be better done than if by extra gangs. The extra gang is not acquainted with the roadbed or track or traffic. The extra gang foreman must make a showing of speed if he is to hold his position. There is no comparison between extra gangs, except in the amount of work done. The extra gang foreman has usually more men than he can watch and teach, and keep doing as much and as well as they should. The section gang has all the advantage of more supervision per man, of knowing the track, the climate, the traffic, the weak spots in the ballast, and the soft spots in the roadbed. They need little telling about what to do or how to do it, if they are permanent employes. It seems reasonable to suppose that such section gangs might do much

of the work now so poorly done by extra gangs. The slower speed of the permanent gangs would be more than made up in the quality of work done.

Piece Work.—Piece work is done in many factories and in railway shops. There seems no reason why all railway companies should not do a great deal of maintenance on the piece work plan. Some are doing so now. Putting in ties by piece work has increased the number of ties placed by one man in a day by about one-third, on some roads, and the men's pay has been increased accordingly. Gaging track, building fence, and most other maintenance work can be done on the piece work plan. There is no reason why a good trackman should get the same wages as a poor trackman. If he worked by the piece he would get just what was due him. There would be a proper basis of comparison and the money spent for track work would be better spent and bring better results. Winter track forces could do nearly all their work on this basis and they could do a great deal of the work which is now done in summer on most roads.

With better men and better methods there would be better results. This is not theory only. These things are being done and are showing increasingly better results in comparison with the old ways, where there is no possibility of other comparison.

Good Tools.—Good work cannot be done without good tools. Good tools cannot be bought as cheaply as poor tools. Even good tools, unless they be kept in good repair and condition, are not fit to work with, nor can good results be obtained. A good workman will not be satisfied to work with poor tools. Not infrequently trackmen buy tools of their own rather than

get along with poor tools furnished by the railway company. This spirit has led many track foremen to buy motor inspection and section cars, and gasoline engines. Saws, scythes and hammers are often bought by section foremen for railway use. To a workman who knows his tools and how to sharpen them, there is no more valuable help than a good grindstone, with the necessary attachments to keep all kinds of track tools sharp.

Winter Tools and Materials.—Every section should go into the winter with a full stock of shims, braces and spike to last through the season. Salt is important especially about switches and crossings. Adzes and hand axes are needed and should be sharpened frequently. Claw bars, spike pullers, spike mauls and track wrenches are all important in the winter day's work, as are the shovel, pick, snow shovel, ice scraper and nearly all the tools used in summer.

Winter Work.—On many roads, the tightening of track bolts is a summer job. It is quite as important in winter and should be attended to much oftener than is the practice generally, both winter and summer. The oiling of track bolts will help in the life of the bolts and in the ease with which they can be tightened. There is no excuse for loose track bolts. They get loose only through inattention. Unfortunately we in America have become used to this carelessness. Our tracks are so badly abused by overloading, and our track forces so cut down for "economy" that we do the best we can with what we have and let it go at that. The results are painful to see and not always safe. Who has not seen track spread because no spikes were to be had; or rails turn over which were not drilled because no drill was available; or track too rough for speed because no shims

were on hand; or high snow drifts on rails because snow fence could not be had? These conditions would almost surely improve with the employment of more trackmen in winter, with the element of permanent work, of comparative results and the introduction of piece and contract work.

Grading Wages.—The work of trackmen may be improved by the proper grading of wages. There is always a best man in every gang. Why should he work for the same wage as the poorer workmen? What encouragement has he to do all he can do, if the others get as much money for doing less? The chances are that he not only will not do all he can, but that he will quit and go to some other job which offers better inducements. For this one reason the track foreman loses most of the best men hired. One of the great needs of the maintenance department is the grading of wages, so that the men have some reward ahead for doing better work than their fellow workmen. There is generally a scarcity of track foremen. The grading of wages will go a long way toward solving this problem. If the best man in each section gang is paid a little more than the other men, he will try to learn the business, knowing that from the best men or subforemen, vacancies for the position of section foreman will most likely be filled.

Getting Over Tracks in Winter.—Track inspection and the taking of men and tools to and from the places where track work is to be done takes time and labor, necessary to be sure, but from which there is no direct return. When the number of laborers is large enough, and the work is such as to demand road train service, the problem seems simple. The men with their tools are put on the train at the appointed place and put off when

the road train reaches the place where the track work is to be done. This would be easy enough if locomotives and cars and enginemen and trainmen were always ready, and if there were no other trains on the road so that orders to go were always on hand. Every trackman is familiar with these difficulties. In winter they are increased, as extra power is needed, crews may not be prompt, engines come out of the house slowly, tracks may be obstructed with snow, and coal and water are not so readily obtained as in summer. In winter the trackmen must have heated cars to ride in, and tools need some extra care.

But the hand and gasoline cars which are run by their own power have the most trouble in winter. The man-propelled hand car, formerly the only car used for track work, is still largely used on maintenance and construction. Though it is hard and slow work to pump these cars over the track under the best of conditions in summer, they can be quickly taken off the rails; and as they are not run on train orders, many of the delays which effect road train travel are avoided by the use of hand cars. On the other hand, when cars obstruct the track, hand cars must wait or be carried around the cars, whereas a road train can often proceed after switching the obstructing cars. It is possible to get a hand car over a string of empty flats by placing a pair of rails or other skids with one end on the running rails and the other end on top of the cars in order to push the hand car up onto the first flat car and down off the last flat car. It is sometimes possible also to pinch a string of cars past the hand car after lifting the latter off the track. This is usually not advisable on account of the danger of not being able to stop the cars after they get

going; on account of the time and labor it takes and because the freight cars may be spotted by direction of shippers.

There is danger in running hand cars and all trackmen are familiar with the precautions necessary to keep out of the way of trains, especially on sharp curves where the view is obstructed, in windy and foggy and snowy weather and at dusk or after nightfall. Careful flagging and the display of lights and signals is most necessary. Trackmen soon learn the importance of keeping a continuous lookout to the rear as well as ahead of a hand car when on main tracks. The rule that a hand car must be removed from the rails when not in use should be strictly obeyed if trouble would be avoided. If a hand car with men and tools makes eight miles an hour over track including stops, a round trip of four miles and back will take an hour or one-tenth of the time of a gang working a ten hour day. Therefore, any scheme which will reduce the time so lost is money and labor saved, in which both the company and employes are directly interested. The motor hand car has been introduced for this purpose, and is coming into quite general use.

In winter the troubles of running hand and motor cars are multiplied. Car wheels slip on frosty or snowy rails so that it is very hard to start a car or to keep going. Running behind trains assures a clean rail for a short time only. To make fair headway in snowy weather hand cars must be supplied with something to sweep or scrape the rail clear of snow ahead of the wheels. Iron castings that may be screwed to the forward ends of the frame of the car over the track rails and have sockets and set-screws to hold broom handles

are used. The broom is a short, worn corn broom with the handle sawed off making it about 18 in. long. When the car is taken off the track these brooms drag along the ground unless they are raised, which takes time. An improved broom holder is fitted with a bolt, spring and hinge device so that the brooms may be turned and held in a horizontal position with the broom end point-

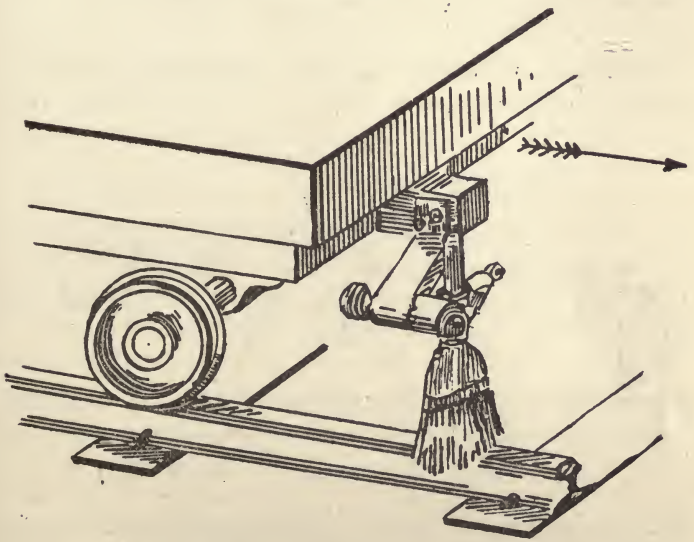


Fig. 6—Hand Car Broom Holder.

ing frontwards, so that the car may be taken off the track without raising the brooms. This broom holder is very handy, costs little and weighs only 5 pounds. See Figure 6.

A steel brush similarly fastened to sweep the rail ahead of the wheels, with a lever to operate it, is used on hand or motor cars and is valuable not only for snow,

but for brushing stones or other obstructions from the rail. (Figure Railway Age Gazette, p. 310, Vol. 52, No. 7.)

Use of Sleds.—On northern railways, sleds are used on sections where hand cars cannot be used in winter on account of heavy grades and sharp curves. Tools and shims are carried by the section men who walk, snowshoe or ski to the place where their work is to be done, pulling the loaded sled by hand.

Operation of Motor Cars in Cold Weather.—Any gasoline engine is harder to start when it is cold than

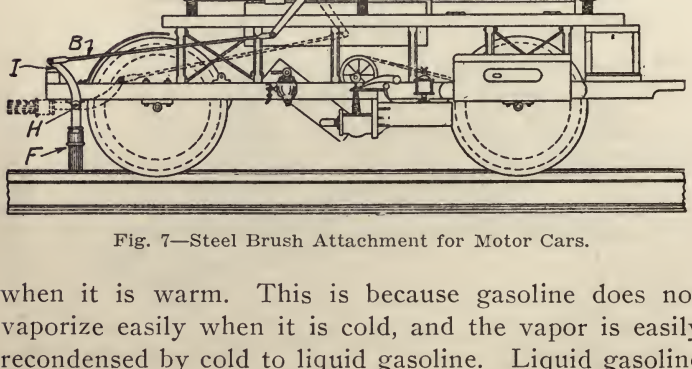


Fig. 7—Steel Brush Attachment for Motor Cars.

when it is warm. This is because gasoline does not vaporize easily when it is cold, and the vapor is easily recondensed by cold to liquid gasoline. Liquid gasoline will not burn; it must first be vaporized. When an engine is started in cold weather, therefore, there is only a small charge of gasoline vapor in the cylinder when the spark is flashed across the points of the spark plug, and a large part of what little vapor the carburetor does supply is recondensed against the cold walls of the intake pipe, cylinder and piston. If a few charges can be

secured which are large enough and rich enough to be fired and start the engine, the cylinders will usually get warmed and the engine will then take care of itself and run as usual. It is therefore advisable in cold weather to do something to produce the first half-dozen explosions, which is not necessary in summer.

In the first place, heat the carburetor itself. This is safely done by pouring warm water over it or by wrapping a bag of warm salt or sand around it for a few moments. Do not use a torch or live coals as there is danger of an explosion. After the carburetor has been warmed, a half thimble full of gasoline should be injected into each cylinder through the priming cup, and the cup should be closed. This is called "priming the engine." The carburetor should then be "flushed" or "flooded" with the little plunger. If, now, the crank shaft is turned over, the engine will seldom fail to start. Of course, do not forget to have the gasoline turned on, the switches closed, and the throttle open.

In winter, especially, get good gasoline if possible, as the higher the grade the more easily the gasoline vaporizes. It is also a fact that the higher the grade the harder it is to get, but if at least 58 deg. or 60 deg. gasoline is not furnished for ordinary use, it will be best to get a small amount of higher test, if possible, for priming purposes. If a high test gasoline cannot be had for ordinary running, it is a good idea to try to at least have some of it on hand for priming, and to carry a small quantity of it in a bottle or squirt can. On extremely cold days warm this gasoline before using, by holding the bottle or can in hot water for a minute or two.

There is another liquid called sulphuric ether often

more easily bought than high test gasoline, as it can be purchased at any drug store, and which is good to prime with, as it is much more easily vaporized than gasoline. It is also much more explosive, and greater care must be taken in its use. It costs more than gasoline.

Many of the motor cars on the market are of the two-cycle type, and the oil for the engine is mixed with the gasoline before it is put into the gasoline tank. This gives a good chance to get warm gasoline for starting. The oil is usually mixed one pint of oil to five gallons of gasoline, or with some oils as much as one-half pint of oil to the gallon. In cold weather the oil may be warmed before mixing it with the gasoline. This gives a tank of warm gasoline to start, without any danger of explosion.

Usually there is some water mixed with gasoline which often separates, and as the water is heavier it settles in the low points of the pipe connections to the carburetor or in the carburetor itself and then freezes, blocking the pipe and preventing the gasoline from flowing. To find out whether this has occurred, flood the carburetor, and if gasoline flows continually the pipe is probably clear. If it is blocked, heat the low points to melt the ice. Even in warm weather it is a good plan to strain all gasoline used through a chamois skin to remove the water, but in winter it is an extremely good plan, as it will prevent trouble with frozen carburetor and feed tubes. Gasoline flows slowly through a chamois skin, and it may be found that it will take too long to strain it at the time of filling the tank, so it is a good plan to have an extra gasoline can and strain the gasoline into it at convenient times, then fill the tank on the car from that can. Another way to prevent freezing is to drain the carburetor

and feed tube at night after closing the gasoline tank shut-off cock. The gasoline thus drained out may be caught in a cup and poured back into the gasoline tank.

It is a good plan in cold weather to warm up the engine in the car house by running it a moment or two there before taking it out into the colder air. On cars which have a clutch for freeing the engine from the driving mechanism, this is simple. With the direct driven type of cars such as is largely used for section and extra gang work, where the driving axle forms the crank shaft of the engine, or is directly connected to it by gears or chain without a clutch, the engine may be run in the car house by raising the engine end of the car and sliding a box under it so that the driving wheels will not touch the floor; then starting the engine by turning the driving wheels with the hands. The engine will start more easily this way without a load than by pushing the car on the track, especially if the rails are frosty.

After the engine is once started and warmed, it usually will operate without trouble, but a gasoline engine always runs on less gasoline in warm weather than in winter. On water-cooled cars it is a good plan to reduce the cooling capacity of the radiator during the winter. This is easily done by covering part of the radiator with a piece of oil cloth or canvas. The water will continue to flow through the entire radiator, but air will be drawn only through that part which is not covered by the cloth, and where there is no air there is no cooling. In this way the cooling capacity of the radiator can be reduced as wanted. Be careful of water-cooled cars to see that the water does not freeze in winter and burst a cylinder or radiator. An anti-freeze solution is

the best thing to use. The following table gives the freezing points of anti-freeze solutions made by mixing alcohol, glycerine and water.

Wood Alcohol	Glycerine	Water	Freezing Point
5 per cent	5 per cent	90 per cent	25 deg. above zero
10 per cent	10 per cent	80 per cent	15 deg. above zero
12½ per cent	12½ per cent	75 per cent	8 deg. above zero
15 per cent	15 per cent	70 per cent	5 deg. above zero
16½ per cent	16½ per cent	67 per cent	15 deg. above zero
10 per cent	----------	90 per cent	18 deg. above zero
20 per cent	----------	80 per cent	5 deg. above zero
25 per cent	----------	75 per cent	2 deg. above zero
30 per cent	----------	70 per cent	9 deg. above zero
35 per cent	----------	65 per cent	15 deg. above zero
----------	10 per cent	90 per cent	28 deg. above zero
----------	30 per cent	70 per cent	15 deg. above zero
----------	40 per cent	60 per cent	5 deg. above zero
----------	50 per cent	50 per cent	2 deg. above zero
----------	55 per cent	45 per cent	10 deg. above zero

Ordinarily an engine that has run well all summer will begin to miss explosions as the cold weather comes on. The principal reason for this is that cold weather not only affects the gasoline, but it also slows down the dry batteries which operate the electric igniter on the engine. The oil also gets hard and stiff and makes an engine hard to crank and start. If an engine gives trouble in cold weather try the following tests, if possible, before sending the car in for repairs:—Take hold of the fly-wheel on the engine and turn it around slowly by hand until the crank shaft comes to a position of about 12 degrees below its inner dead center. At this position the igniter should trip off, and if you find that it does not trip off at this position, it will be necessary to change the timing. This is usually done by simply lengthening or shortening a tripping device which is attached to the engine. Lengthening the trip rod will make the igniter snap off earlier and shortening up the rod will make it snap off later. If you find that it is impossible to change the timing by adjusting the timing device, it may be necessary to change the cam gear

which operates the timing of the igniter and the valves. Moving the gear one tooth at a time forward will make the igniter snap off earlier, and turning the gear one or two teeth backward will make it snap off later. The timing of the igniter is one of the most important things in operating an engine. If the igniter is properly timed, the engine will give good power. If the igniter is out of time, the engine will give very little power.

The igniter should be taken off the engine and the two wires from the batteries attached to it. Then, the igniter should be snapped by hand and notice taken of the spark at the contact points. If the batteries, spark coil and igniter are all in good condition, a good fat spark will be obtained at the contact points. If there is any defect in any one of these a good spark will not result. If the spark is weak the batteries should be examined. A battery can be easily tested by an ammeter. The ammeter should show at least six or eight amperes for each battery cell, otherwise the batteries are too weak to operate the engine. In cold weather the battery current is lower than in warmer weather, which is due to the fact that the chemicals inside the battery do not work as actively when cold. The batteries should be kept in a warm dry place so that they will have a good current to start the engine. They should not be kept too warm, otherwise they will be spoiled because the chemical inside them will evaporate and dry them.

Next the spark coil should be examined for any broken connection at the coil itself or a short-circuit in the coil. If the coil has a broken wire inside, there will be no spark at the igniter points when it is snapped by hand, even with a good strong battery. If there is a short-circuit inside the coil, a weak spark will result at the

contact points with a strong battery, but not a heavy spark. The coil itself needs very little attention except to keep it from getting wet. All the wires that are connected between the spark and the battery and the igniter should be examined and the binding post screws should be clamped tight so that they do not jog loose when running on the road. All of these little brass nuts should be tightened up with a pair of pliers so it is impossible for them to work loose. The one contact point should be thoroughly insulated from the igniter body. Ordinarily these points or bolts are insulated from the iron body of the igniter by mica washers. The mica washers must be thick enough and large enough so that no metal whatever reaches from the insulated hole to the body of the igniter or to any part of the engine. Mica washers must be kept clean from soot and carbon and it is a good plan to remove the igniter every week and scrape all the soot, rust and carbon off the electrode and the mica washers. The contact points of the igniter are made of a high grade alloy which will withstand intense heat. This alloy is a bright metal and must be kept thoroughly clean so that the contact will be good. These points can be cleaned with sandpaper or with a small file and should be inspected every week. If they get worn so that the contact touches the steel on either one of the electrodes, they should be renewed.

The exhaust valve on the engine should be timed so that it opens when the crank shaft is 40 deg. above its outer dead center. The timing is usually adjusted by simply setting the cam gear in the proper position with the crank shaft gear. A quick way of setting the exhaust valve at time is to set the crank shaft so that it is hanging straight down and then set the cam gear

so that the high point of the cam is pointing directly towards the cylinder head. Then the flywheel should be taken hold of and the crank turned around slowly by hand and notice taken as to whether the exhaust valve opens up at 40 degrees above its outer dead center. There is an adjusting screw which pushes up against the end of the exhaust valve and this screw is used to make small adjustments for wear on the exhaust valve. Screwing in on this adjusting screw makes the exhaust valve open earlier, and unscrewing it makes the exhaust valve open later. Before operating an engine, care should be taken to make sure that the screw is locked by the nut which holds it in place.

To test the compression the fly-wheel should be turned around slowly by hand until the piston on the engine starts towards the cylinder head and is working against the air inside the cylinder. If the engine is in good condition a strong pull on the wheel is needed to pull the crank shaft over its center against the air, but if the compression is weak, the crank goes over easily. Loss of air-compression is due, first, to leaky rings: rings that have become worn so that they do not hold the pressure back: a ring that is stuck in the grooves of the piston: a ring that has turned to where the slot is on top of the piston, or, a ring in which the temper or spring is gone. Take the piston out of the cylinder and examine the rings. They are sometimes worn in the grooves and this will let a lot of pressure escape. The rings should have a spring of about $\frac{1}{8}$ in. to $\frac{3}{16}$ in. larger than the diameter of the piston so they will give enough pressure against the cylinder walls to prevent compressed air escaping.

Leaky valves are caused by natural wear on the valve

seat of the cylinder head or valve chamber, and by the wearing of the head of the valves or by the valves getting pitted or dirty. The only way to find this out is to take the cylinder head off the engine. The valve should be removed from its seat and the valve head examined. If this is not tight the valve should be ground with emery and oil against its seat until it fits perfectly. All emery and oil should be carefully cleaned off before putting the valve back in place. Also the head of the valve should be riveted solid to the stem and notice taken that it has not become loose or worn on the stem. The valve stem must be oiled often.

The packing that is used around the engine is made of asbestos and sometimes this asbestos has a wire woven into it to give it strength. The packing must be very carefully cut out and no cracks or breaks allowed in its face or it will blow out almost as fast as it can be put in. It is well to soak the packing in linseed oil before applying it and then allow the parts to set for three or four hours before using the engine.

Compression is also lost from wear on a cylinder or piston. If the oil is not good the piston and cylinder wear out fast and this lets gas escape. If the piston pin gets loose, it will work itself out and scratch the side of the cylinder so that all the gas may escape.

Be sure that the lubricator on the engine is full of oil before starting. The oil used is a mineral oil which has a high fire test. Ordinary machine oil or steam engine oil will not work on a gasoline engine because the heat from the explosion is so intense that it burns up the oil and does not allow it to oil the cylinder. After the lubricator has been filled it should be set so that it will drop steadily about ten to fifteen drops a minute. Both

glasses must be kept clean so as to see whether the lubricator is full of oil and working right. Before starting an engine in cold weather it is well to take the lubricator off the engine and hold it near a fire to thaw out, because if the oil is cold and thick the engine may be burned before the oil gets warm enough to oil the piston. There is a little screw in the bottom of the lubricator that can be set with a screwdriver. Turning this screw up will prevent the ball from lifting so high that gas gets past the ball, smoking the glass and preventing oil dropping. If the ball should be screwed up too far then the lubricator will drop oil down into the lower glass and will fill up and so oil will flow out of the lubricator. Unscrewing the adjustment about one-quarter of a turn will fix this.

Lubricators are packed with cork washers and these must be kept tight and screwed down so that the pressure through the little brass tube inside the lubricator can get on top of the oil and balance the pressure underneath the drop of the oil that is flowing out of the lubricator tube. If the pressure tube in the lubricator gets clogged, then the oil will not flow.

Grease cups furnished on engines are of two kinds, the cap to screw down by hand and the spring feed cup. To fill the cup, unscrew the cap, fill with grease, and screw down the cap on the stem. There is a small adjusting screw in the stem of the grease cup which has a hole through it to regulate the amount of grease passing down through the stem. If the slot on the screw is straight up then the cup is wide open, but if the slot stands crosswise of the cup, it is closed. In cold weather these cups sometimes get clogged from grease being too thick and hard. Clean them out and

put in thinner grease by mixing the ordinary grease with lubricating oil, or get a grade of grease that is adapted to cold weather.

In very cold weather the mixer pipe on the engine may freeze because the air in passing through the small pipe opening travels so fast that it gets very cold. An engine used a great deal in very cold weather should have a hot air pipe attached to the mixer which will allow the air drawn into the engine to be taken from near the warm walls of the cylinder. This will help to prevent trouble.

A squirt can may be filled with gasoline and then put into a pan of boiling hot water. This will heat the gasoline in the squirt can without any danger of the gasoline catching fire, and the heated gasoline can be used in starting in cold weather. Some of the warm gasoline can be squirted into the bottom of the mixer or through the priming cock on the engine. A great deal of care must be taken that the can of gasoline is not exposed to fire as heated gasoline will catch fire very much easier than cold gasoline.

When shutting down the engine and putting it away for the night or allowing it to stand for any length of time it is best to throw a heavy blanket over the cylinder to keep the cylinder walls hot. Any heat around an engine will help in getting started. All hand car engines should have tight side curtains or should be boarded up solid. These curtains keep the heat inside and keep out dirt and dust.

Sometimes an engine will not work because the gasoline pipe is clogged with dirt or scale. Dirt gets into the gasoline when filling the tank and it does not take very much of it to cause trouble with the needle valve.

The valve hole is very small and any grain of dirt or sand may prevent the gasoline from getting into the mixer. Sometimes scale from the pipe breaks off and floats along with the gasoline, is carried up to the needle valve, clogs the hole and prevents the gasoline from getting into the mixer. This dirt and scale sometimes gets underneath the check valve in the gasoline pipe and prevents the valve from dropping back into its seat and this causes the engine to flood. Dirt or ice gathering around the seat of the check valve will prevent the gasoline from flowing through freely, and will make the engine act irregularly.

The connecting rod bearing to the crank pin should be watched. This bearing gets severe strain and hammering from the crank shaft when reversing the motion of the piston. If this bearing gets loose it may cause a serious wreck of an engine, for the hammering of the plunger and reciprocating parts will break the bolts that fasten the cap to the connecting rod. The cap is drawn up against metal shims or thin liners and if it starts to pound it will be necessary to take one of these liners out from between the cap and rod and draw the cap down so there is no play between the bearing and the pin. The main bearings are those that the crank shaft runs in and are part of the main frame of the engine. Should these bearings get loose, the crank will pound on the frame so hard that it will finally crack it and probably break the crank shaft.. These bearings should be examined every day. More engines are broken because of loose connecting rod bearings and main bearings than from any other cause. The life of the engine will be much longer if these bearings are watched and kept tight.

During cold weather an engine cranks harder than in

warm weather because oil and grease is hardened. Great care must be taken in cranking an engine in cold weather as the igniter may explode the charge before the piston comes up to the center, and kick backward, and is likely to throw a starting crank around and break the arm of the operator. A firm hold should be taken of the starting crank and a good swift whirl given it, especially at the time that the engine is about to trip off the igniter.

If the mixture of gasoline is too weak it usually explodes with a loud noise in the mixer. This is backfire and shows that the throttle needle is not opened wide enough. A lean mixture is also indicated by a weak explosion or by the engine missing explosions. If a check valve gets stuck or if the valve has worn badly, the mixture will be too weak and the engine will not explode properly. This weak mixture may also be caused by either dirt or ice getting into the pipe or into the gasoline nozzle.

If there are any explosions in the muffler of an engine they show that the gasoline mixture is too rich and that some of the gasoline should be shut off. If there is smoke coming out of the exhaust pipe or muffler this also shows there is too much gasoline being fed to the engine. An engine that runs with a lag or slow explosions has too strong gasoline. If the needle valve is too far open the amount of gasoline drawn into it at one charge is too much for the amount of air, and it should be shut down part way.

Most trouble comes from ignition, loss of air, oiling and loose bearings. If these points are watched carefully and kept in good condition, the engine will run well.

Above all other things, keep the bearings tightened and don't let the engine pound.

CHAPTER VI.

SNOW FENCES AND SNOW SHEDS.

Railway snow fences are barriers put up to keep snow from drifting onto the tracks.

In many ways and with many different materials, the people of various countries have for years built barriers to keep wind-blown snow from obstructing traveled ways. These barriers are sometimes permanent, but more often temporary, depending on the circumstances under which they were built and used.

Kinds of Snow Fence.—Blocks of snow, cakes of ice, ridges of earth, squares of sod, brush fences, fences of old ties, rail fences, open board fences, tight board fences, panels of portable board fence, dry stone walls, masonry walls, brick and concrete walls, rows of trees and hedges are all used for this purpose.

Location of Snow Fences.—In America the snow fence most commonly used is made of wooden boards. It does not take highly skilled labor to make snow fence; but it does take a person of skill and experience in handling snow and a person well acquainted with the action of the winds in the particular locality where the fence is to be used to tell just how and where it must be set to do the most good. A great deal of actual harm can be done with snow fence wrongly placed. Too much snow fence is usually worse than none at all. The very careful keeping of records of the results of placing snow fence to protect track is of great value because it shows the action of the wind in driving the snow, and of the quarters from which it may be expected in winter storms. No two storms are

exactly alike. Certainly no two winter seasons are quite alike. Therefore, until records are completed covering several years' storms, it is not safe to erect permanent snow fences for railway use. These records should give dates and duration of storms, the position and height of snow fence erected at each locality to be protected, necessity for changing position of fence, direction and intensity of wind, changes in wind and effects of moving or altering fence.

At the close of the winter season the snow fence program for the succeeding year should be carefully made out while all the details of the snow fight are fresh in the minds of those interested.

Snow fences are placed on the windward side of the tracks which are to be protected, and in such position as to effectively stop the snow. If possible, they are set exactly across the path of the prevailing winter wind.

Board Snow Fences.—Fences made with wide spaces between the boards are intended to stop the snow between the snow fence and the tracks. The fence partially stops the wind, making an eddy which gives the air currents an upward motion so that the flying snow jumps the fences and alights on the leeside, between the fence and the tracks. This snow drifts into a pile with a long slope, about 15 to 1, depending somewhat on the force of the wind. A tight fence or wall will stop the wind entirely, making it whirl the snow over and back like surf on the shore. This snow falls on the windward side of the fence, where it piles up close against it with a slope of 3 to 1 to 5 to 1, according to the strength of the wind. After the drift reaches the top of the tight fence, snow coming later will blow over the fence from the windward to the lee side. Blowing up the 3 to 1 slope of the drift

on the windward side, the snow will blow further over the top of the tight board fence than it would go over an open fence. If there is room to properly place a snow fence, there is little to choose between an open and a tight fence, so far as the amount of snow they keep back is concerned.

There are other considerations, however. A tight board fence costs more than an open board fence of the same dimensions. Again, open snow fence is portable when made in separate panels that can be carried about and set to suit the winds and tracks. These separate panels of portable or temporary fence have this advantage: they can be set exactly at right angles to the wind if desired and not parallel to the tracks, and with spaces of about 2 ft. between panels for the sake of economy.

Because snow piles up between the open fence and tracks at a slope of 15 to 1, it follows that an open snow fence should be set 15 ft. away from the tracks for each foot of height of the fence. A 6-ft. high, open fence should be set 90 ft. from the track. If set closer, the snow will encroach upon the track. Most often, the rights-of-way of railways are too narrow to permit placing even low fences far enough from tracks to get the best results. The usual width of right-of-way in America is 100 ft., although it is often narrower and seldom wider. When a right-of-way is too narrow, it may sometimes pay to erect a high, tight fence at the boundary line, provided permission cannot be had from the adjacent property owners to place portable snow fence on their land in winter, to be removed in summer. Portable fence is often moved during a winter's season. It may be moved back from the tracks after holding a drift to the limit

Fig. 8—Portable Snow Fence.

of its height, or it may be moved to better face the winter winds.

Portable Snow Fence.—The portable fence is made usually of rough lumber 1 in. by 6 in. by 16 ft., placed horizontally with spaces 6 in. wide between boards, on two by fours, as posts. See Figure 8. These posts are not upright, but slant backward to meet the rear posts which lean forward and are about two feet longer. The top three or four boards of the fence are carried on the extension ends of the rear posts, so that the top of the fence leans forward. The front and rear posts are held by bolts to each other and the fence panels are easily folded for piling when not in use. This portable fence is a safe and handy protection, especially when the winds are variable and the climate not absolutely well known.

Snow Boards.—Snow boards are frequently placed on the ordinary railway boundary fence to protect tracks from snow. If a permanent snow fence is to be built on a boundary line, it should be made to serve both purposes, protection against snow and protection against stock, as there is no use having two fences where one will do.

Permanent Snow Fence.—Permanent snow fence is built on posts set in the ground. It may have open spaces between the horizontal boards, or the boards may be set close together with the edges touching. See Figure 9. Tight board fence may have its boards placed upright or level. The posts of permanent fence are often staggered, the post in the middle of each panel being set on the side of boards away from the track, all others being on the track side. With such staggered posts, boards cannot easily be taken from the fence, nor can the fence be easily weakened.

On account of danger from fire, the bottom board of snow fence should be at least 9 ins. and preferably 12 ins. clear of the ground. This small space is not important because the snow will quickly fill it. Permanent fences are usually built on the right-of-way boundary

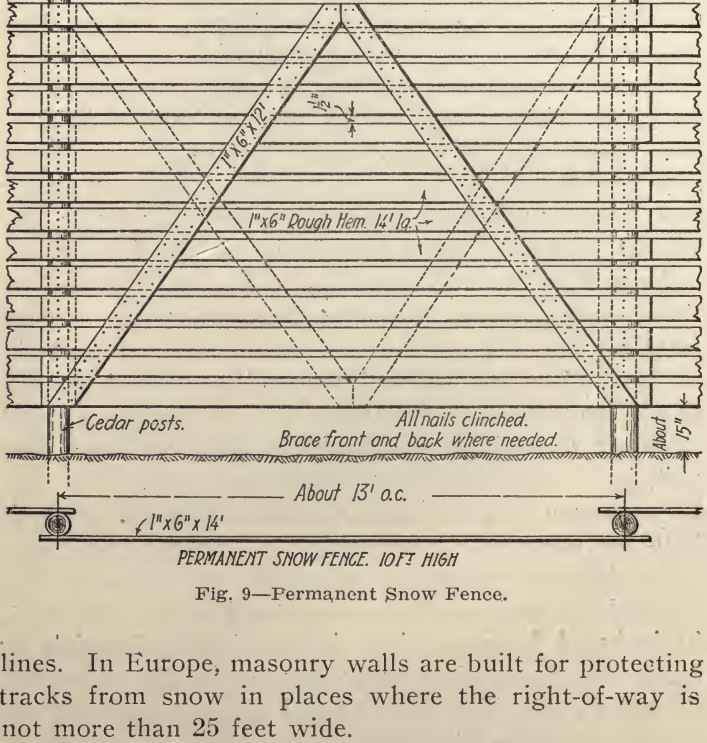


Fig. 9—Permanent Snow Fence.

lines. In Europe, masonry walls are built for protecting tracks from snow in places where the right-of-way is not more than 25 feet wide.

In case of drifting snow, as well as of many other troubles, an ounce of prevention is worth a pound of cure.

Avoiding Necessity for Snow Fence.—To do away

with the necessity for snow fences, new tracks may be constructed to a high grade line so as to make the top of the rail above the surface of the average depth of snow. In snowy countries, track which would be ordinarily laid on the ground, is laid on 3-ft. banks, so that the snow blows away instead of lodging against and drifting over them.

The plowing of snow should be done in such a way that the snow moved will be thrown clear of the roadbed. To do this the snow plow must be run at a high rate of speed or some snow will be dropped and will form snow ridges at the tie ends. These ridges stop drifting snow and make it fill the tracks. A heavy wet snow can scarcely be thrown 50 feet with a Russell plow going 50 miles an hour. In spite of all precautions, snow ridges will gradually appear near tie ends as the season progresses, and they should be spread back if possible to avoid danger of the track filling up between the ridges.

Where the track is through cuts the slopes should be made flat and the roadbed should be raised about 3 ft. so as to look the same as in fill. This gives the same advantage over snow as embankments. The immense advantage of building a railway in snowy country with due allowances made for snow fall, snow drifting and snow plow ridges, can scarcely be estimated, for the expense of fighting snow is enormous and far reaching. The expense of snow handling in late winters depends largely on what has been done in the early winter months. Then it is that most careful work must be done to provide room for the snow of the severe storms which are expected to follow. Too often only the present is considered, while the snow of successive storms gradually closes in more and more until serious trouble results.

Hard, high center in tracks is the result of lax plowing in early winter. It is extremely hard to get people interested in winter work during a summer season. Snow fence, however, should be made in summer and be ready for use when the winter season approaches.

Shallow cuts which lie broadside to the prevailing winter winds are most likely to drift full of snow. Deep cuts through abrupt hills give comparatively little trouble in winter because the hill divides the wind, which goes around on each side of the cut. The shallow cut, on the other hand, causes an eddy to form from the wind blowing over the cut, and the snow falls from this eddy into the cut and fills it rapidly. There are cases where snow fence is needed on each side of a track. Hard winds that blow from opposite or different quarters make fences necessary on both sides of a track. The posts of permanent snow fence should be set deeply into the ground to prevent heaving from frost, and to resist the force of winds and pressure of snow from the windward side. Snow-fence boards should be securely nailed to the posts on the windward side.

Other Types of Snow Fence.—Blocks of hard snow are piled up as in a dry stone wall, for temporary protection from snow drifting in winter. Cakes of ice are similarly used. Ridges of earth are thrown up from the trench formed on the windward side by removal of the earth. Sod fences are made in much the same way as ice walls. Brush fences are made by placing the branches side by side with tops toward the wind as high as needed, and with butts weighted with dirt or rock. An objection to brush fence is that in summer it becomes a fire trap which cannot be easily moved. If brush fence is used, it is well to clear a fire path all around it for

the summer, throwing the earth onto the bottom ends of the boughs. Old ties are sometimes stood side by side and on end in a shallow trench, to protect tracks from snow. Hedges are usually planted at the right-of-way lines. Walls of brick and masonry are placed in the same relative positions. Trees are sometimes planted in fairly big groves to replace the virgin timber which would have protected the tracks from snow. Cone-bearing or evergreen trees like the balsam and cedar, if planted in a climate where they grow well, are suitable for protection against snow, when planted several rows deep and staggered so that the trees of each row stand behind an open space of the row in front. Trees form an effective protection especially when trimmed so that limbs grow close to the ground. Hedges should be top trimmed to make the plants grow low and bushy, not more than 5 or 6 ft. high.

Cost of Snow Fence.—The cost of wooden portable snow fence has been estimated at $3.50 per rod. As a matter of fact, such fence was made in 1915 for $2.50 per 16 ft. panel. Loading, transportation, unloading and setting in place brought this cost up to $2.80; and 25 per cent overhead expense added 70c per panel, bringing the cost at $3.50. To this should be added the yearly cost of piling and resetting of not less than 30c, a maintenance cost of 20 per cent and interest on investment at 5 per cent, or an actual total cost of about $4.75 per panel including a slight cost for loss by fire.

On account of this cost, which amounts to $150.00 per mile of fence if panels are set 1 ft. apart, it has been argued that the planting of trees and hedges is advisable. Some of the stronger railway companies of the north have experimented with these "live" snow fences on the

basis of comparative economy. The fire risk is probably less with growing timber and shrubs. The maintenance is less in some cases and in time the timber may have commercial value, especially for fence posts and ties.

On the other hand extra right-of-way would in most cases be necessary to keep the inside of the plantation 100 feet from the center line of track, the strip planted being about 60 ft. wide. The land must be plowed, the trees and shrubs must be known to thrive well in the region to be protected, and expert supervision given.

The cultivation of the ground has been described as first a four inch plowing, followed by disk harrowing or rolling in spring and backsetting to about the same depth in autumn. In the spring of the second year the land is deep plowed, say 14 inches, and planting is done in the spring of the third year. The shrubs are planted on the outside and trees on the track side. Willows are recommended, as they will grow limbs close to the ground if properly pruned. Evergreens are effective where they will grow well. In alkali ground plantations have not thrived. In some cases it is possible to lease a perpetual right to maintain groves. Considering the cost of right-of-way or lease, the care and class of labor demanded, and the nursery expense, it is doubtful whether very many railway companies will go extensively into such ventures in the near future, but as timber becomes more expensive and permanency of fences more desirable, the tendency toward tree planting for snow protection will undoubtedly increase.

When a fence or other barrier for snow protection cannot be placed far enough from the track for the best results, then it should be built tight and high with a view to holding snow behind or on the windward side.

As snow held on the windward side takes a steeper slope than lee-side drifts, the fence must be higher to control a given amount of snow. Where heavy snow fall and strong winds prevail, two or more rows of snow fence are needed. Where there is room these fences, usually of the portable variety, are placed about 100 ft. apart, all parallel to the tracks. When the snow has drifted as high as the fence, the fence is of no further use in that place and may be moved up on top of the snowdrift if far enough from the tracks. In late winter a great deal of snow fence is so moved, snow walls are built and added to, and brush fence is made on top of snowdrifts.

Wide Cuts.—The older railways have relatively less trouble with snow than new lines because it is found economical to widen embankments before re-ballasting, and this earth is most easily obtained with ditching machines or steam shovels from the narrow cuts along the line, thus providing a wider roadbed in both cut and fill, by one operation. There is a tendency, however, to slight the taking of material from the shallower cuts, because there is not enough of it in any one stand of the shovel. As these are the cuts which give most trouble in winter, it is well to stop the ditcher long enough to suitably flatten the slopes, widen the cut to the grade point at each end, and leave the track on a roadbed in the middle three or four feet above the bottom of the ditches. In cleaning ditches, trackmen should be rigidly required to take the refuse material out of the cut on a push car and place it on the slopes of the nearest fill below the level of the bottom of the ballast, instead of throwing it up on the banks of the cut, from where it will wash back into the ditches on

gradually form a ridge on top which will in effect deepen the cut and make it catch more snow.

Ends of Snow Fences.—A great deal has been said in favor of turning snow fence ends in toward the track to protect the cuts from snow-drifting, with winds blowing almost parallel with the tracks. The theory sounds well, but in practice it is only in exceptional cases that it does any good. In most cases, turning snow fence ends toward the track results in more harm than good. As a general thing it is not well to slant more than one end-fence panel in the direction of the tracks.

Driftwood is found in streams in spots where eddies are formed by some obstruction which turns the current so sharply that the water whirls about in a circle or whirlpool. Exactly the same thing happens to make snowdrifts. Some object in the path of the wind stops the current or whirls it, forming a partial calm. Then, of course, the snow which is being blown by the wind, whirls about and falls to the ground, and so gradually forms a snowdrift.

Location of Buildings.—Not only snow fence, but any obstruction such as buildings, embankments, or piles of ties, will make snow drifts. Therefore it is best, in all snowy countries, to put all waste banks, buildings, platforms, switch stands and sidings on the lee side of the main track, and if possible, to get all far enough from the main track so that the drifts which form to windward of these structures will not extend far enough to windward from them to cover the main track. If the proper attention is given this matter in the location of buildings in railway yards, especially locomotive houses, turntables and cinder pits, a great deal of winter work in the handling of snow may be avoided. A roundhouse should

never be set facing the winter winds, because the track space between the turntable pit and roundhouse doors will drift full of snow and give endless trouble. As before stated, a turntable pit into which hot water may be

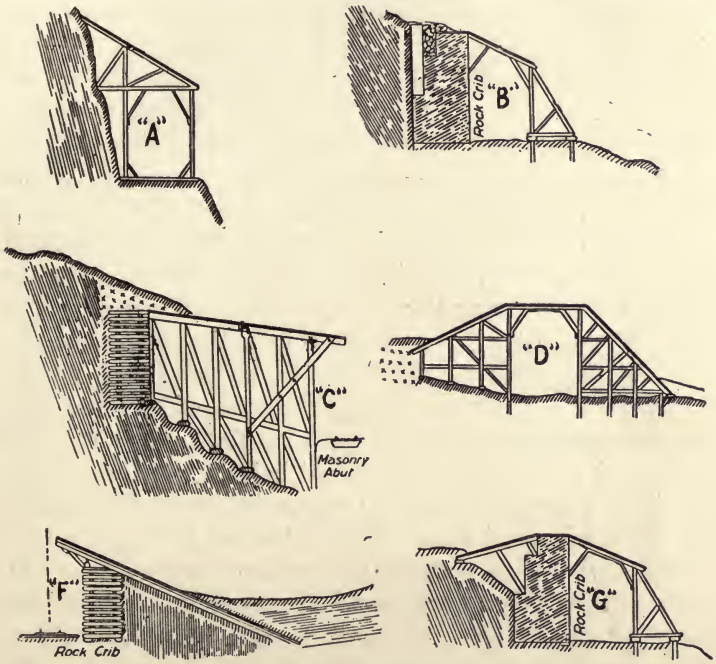


Fig. 10—Types of Snow Sheds.

turned from the roundhouse steam plant, will serve best as a place to melt and get rid of snow from around the house and turntable tracks. A suitable overflow will regulate the height of water in the pit and allow snow water to run away through the sewer.

Snow Sheds.—Snowsheds are built from the upper slopes of cuts over tracks on side hills, usually in moun-

tainous places, where there is danger from snow slides and avalanches, to cover and protect the tracks from the snow, rocks and other debris which is loosened from mountain sides by sliding snow and comes with great force down the long steep slopes, sometimes at the rate of a mile a minute, carrying everything before it. These sheds are built of heavy timbers or masonry on about the same slope as the mountain side above, so as to shoot the snow over and clear of the tracks. These structures must of course be securely anchored on the upper side of the track. Sometimes retaining walls of concrete or other masonry or timber cribs are built to form the up-hill side of snow sheds. These cribs are filled with stones and earth, and similar filling is put in back of the cribs between the cribs and the slope of the cut, making almost a solid wall to take the force of the snow slide. In places where the slopes of the mountain or the railway cut, or both, are too flat or low to make this kind of shed, the snow shed is built not like a lean-to, but so as to form a hump over which the snow will slide. For typical snow sheds, see Figure 10.

Snow sheds as well as tracks need protection. The sheds must be protected from fire as well as from avalanches. Split fences are built on mountain sides above the snowsheds to divide and so break up and stop the slides. Snow sheds are built in short sections and the spaces between are protected by these split fences, which are strong barriers in "V" shape with the point facing up hill.

Fire Protection.—Snowsheds are constantly and closely guarded and sometimes protected by water supplies with hose attachments, by barrels of water, chemical engines, hand grenades, and by fire hose carried on loco-

motives. Ventilation of snowsheds must also be considered. When the sheds are built in short sections they clear themselves of smoke satisfactorily. Otherwise ventilators are provided in the roof, or sides close to the roof.

Expense of Snow Protection.—But with all these schemes for protecting tracks, much expense is incurred. Snow sheds are costly to build and costly to maintain. It is advisable often to spend large sums of money for tunnels to put tracks where there is no danger from snow slides. Another scheme is to try to stop the snow from sliding. If the mountain slope above the tracks is heavily wooded, there is not much danger of snow slides getting started. In the timber the snow does not melt until late in spring, and the standing timber prevents it from getting any start down-hill when it does gradually melt. The worst avalanches are those carrying hard dry snow, packed till it weighs nearly as much as pure ice. This snow usually starts sliding from some slope too steep to hold the increasing heavy weight of old, hard snow, and not on account of melting. If there is heavy timber in the way near the start of the slide, it most often is split and stopped before it gets going fast. Therefore some railway companies have bought mountain lands above their tracks to prevent the timber being cut, and have replanted timber where it was cut over, to prevent slides.

The Track Foreman's Responsibility.—It is not hard to understand that the protection of tracks from snow is an important matter. It is likewise apparent that snow fence is a money saver in winter track work, and that its value depends on how and where and when it is set. Now, there is no one employed by a railway company so competent to arrange this setting of snow fence as the

local trackman. He goes over his section each day. He is familiar with every foot of the track. He knows the cuts and fills and curves; the crossings, sidings and bridges; the owners of adjacent lands, the climate and the direction of prevailing winter winds, as well or better than anyone else, if he is a competent foreman and a man of average observation.

It is true that the trackman has his daily work, has his hands and his mind pretty well full with routine duties every day in the year. But every trackman, however busy, has time to look about him, to think of what is to be done to provide for the winter, and to settle in his own mind the best way to go about it. Right there he very often spoils the whole thing by never letting his plans get further than his own head. It is the duty of the trackman to put his thoughts into words, to put his ideas before his superior officers and to keep at it, in conversation and on paper, till he gets results. It is not necessary to tire out the roadmaster or engineer with these matters. They will usually be quick to see the advantages of those ideas which are good. Results may be slow from other causes, but any trackman with determination and good sense can get permission to set snow fence on farmers' lands, can get the fence to put there, and can tell just how and when and where to set it,—as no one else in the company's employ can do.

CHAPTER VII.

SNOW HANDLING EQUIPMENT.

Methods of railway construction and maintenance have changed rapidly during the last quarter of a century in favor of machine work as against manual labor. The nation's demands for economy, combined with the increasing cost of labor, have stimulated inventions of labor-saving machines. Along these lines, railway necessities have not been overlooked by manufacturers or by the railway companies themselves. Time was when the road train and the extra gang were the railway builders' chief dependences. Then came the steam shovel which could "Choo, choo, and shovel dirt, but could not vote." Followed the track-laying machine, the locomotive crane, the coaling elevator, and many other inventions among which were devices for handling snow and ice mechanically, instead of by the old method of road train and extra gang. Loading snow on flat cars with gangs of shovelers is a slow process, especially in busy switching yards, where the laborers are idle while the road train is of necessity frequently switched about to clear the tracks for other trains. Snow may be mechanically lifted off the tracks, or it may be mechanically pushed from track to track and finally landed in the clear beyond the outside tracks.

In the north and northwest snow handling is a vital matter with the railways. The provision of space for surplus snow and the preparation of the slopes of cuts to avoid the formation of air pockets which cause snow to drift onto tracks, has led northern railway companies

to widen most of their cuts and flatten the slopes. This policy is still being pursued, though machine work has now largely replaced the extra gang, the hand shovel and the work train.

The handling of snow and ice is a heavy responsibility of the track department; for on the preparedness, the foresight, the watchfulness, the determination and the ingenuity of those most concerned in keeping the tracks clear for traffic, depends the ability of the railway to carry freight and passengers.

V-Shaped Push Plow.—Of the machines used for clearing snow from the tracks, the most simple is the V-shaped push plow with vertical sides and no wings. It wedges its way into the snow, which is crowded aside clear of the rails as the plow is pushed along ahead of the locomotive or car. (See Figure 11.)

If the snow is wet, heavy or deep, or if there is ice at the bottom it is not easy to hold such a plow on the track, for the nose will rise and the leading wheels will leave the rails unless the plow is heavily weighted.

Push cars are often made of flat cars, the V-shaped plow being fastened by a beam in front of the end axle of the car. Such a car may be weighted with scrap placed between the car floor and a false floor. At best, such a plow is of use only in countries of light total snow fall, because it cannot throw snow far aside, and its wedge action only piles the snow, at the furthest, at the ends of the wings. And the wings are limited to a few inches beyond the tie ends by the fixed structures along the right-of-way.

A double-track road after being plowed with a push plow would present two clear tracks with a ridge of snow between and a ridge on each side. The two tracks

Fig. 11—V-Shaped Push Plow.

are thus at the bottoms of two trenches of snow and the ridges will catch falling snow and quickly drift full. To get rid of these ridges of snow, the old way was to get the road train with flats and extra gang to shovel them away, especially at yards and at passing tracks. As a yard proposition, this extra gang work is feasible but expensive; but to employ extra gangs and road trains to clear snow from any considerable mileage of single or double-track railway is almost impossible.

Shovel-Nosed Push Plow.—The shovel-nosed push plow is the next step forward in machine invention for handling snow on railways. The shovel-nosed push plow is made to lift the snow off the track (much as a man pushing a shovel in front of him might do) and then throw it aside, over and on top of the snow at the sides of the track. The front of this plow is a cutting edge of steel extending across the rails, just clearing the rail tops and slanting up and back three or four feet to a sharp inclined middle rib with hollowed flaring wings, so designed that the snow lifted by the shovel is parted by the rib and thrown high on each side of the flaring wings of the rapidly moving plow. (See Figure 12.)

Some of these plows have notches for the rail heads in the cutting edge of the shovel end, in order to so lower the plow that hard snow and ice may be scraped from between the rails to a depth of two inches below top of rail. Some such plows have chain and wheel hand gears for raising and lowering the nose to clear obstacles in track, while others have compressed air cylinders with the aid of which the engineer of the locomotive pushing the plow may control the height of its nose.

In countries of heavy snow fall shovel-nosed push plows are built on cars which are enclosed. For further

Fig. 12—Russell Standard Snow Plow with Flanger.

clearing the tracks of snow some of these cars have side wings attached back of the plow. These wings are solid upright plank doors hinged to the sides of the car, against which they may be folded and fastened when not in use. When in use the wings are flared out sidewise the track, either by hand or by compressed air, each wing acting independently on its own ratchet gear, compressed air being much the better because it is quicker. Rapid working of snow plow wings is essential to clear snow close to bridges, cattle guards, switches and other structures without injuring any object. Such work requires an operator well acquainted with the road, and thoroughly familiar with the obstacles and clearances. When worked by hand, the wings of the push plow require at least four men, two to the wheel of each wing. They open and close the wings in answer to bell signals from the operator who sees the line ahead through a window or port in the lookout near the top of the front end of the plow. The distance to which the snow may be thrown from the track depends on the shape of the wings, the speed of the plow and the density of the snow.

Probably the best known push plow is the Russell Plow, which was introduced in Canada in 1885 and used on the Intercolonial Railway for some years before it was used to any extent by the railways of the United States, where it is now operated over many lines. This plow is a large, well and strongly-built machine. It is designed for both single and double-track use, and is built on especially strong trucks and sills. The mid rib which forms the cutting edge starts 5 ft. or more back from the nose of the shovel. The weight of snow carried on top of the shovel is considerable, and the

weight of a drift when the shovel is pushed into and under it is so great that a special truck is used with journals on the inside and outside of each wheel to keep the wheels from running hot. This weight of snow, of course, also bears on the mid rib which must be made of a heavy beam of the toughest kind of wood. A special heavy middle beam or power bar is laid between the middle sills of the car from end to end, the draw bar being on the rear end and the front end framed against the mid rib of the nose of the plow.

The rear part of the Russell plow is a little narrower than the front, so that the snow does not crowd so close as it otherwise would. The doors are at the sides and rear end, and open into a narrow end room. One inside door opens from this rear room into the main room where the wing gears and compressed air cylinders are set. There is a stove, fuel box and tool box in this room. A short stairway leads to the cupola or lookout, which has seats for two, one seat on each side behind a small lever which controls the movement of the wing. There are side windows and front port windows in this cupola. The nose of the shovel, the wings and all parts against which the snow presses are armored with steel plates, the outside surfaces being quite smooth. The outside of the car is made of dressed and matched lumber carefully planed and varnished so as to be as smooth as possible to slip through the snow.

A Russell plow should throw average snow over a fence 50 ft. from the center line of track when going 50 miles an hour. Such speed is of course not always safe, especially in hard or old snow where ice may have formed over the rail. A Russell plow off the track is usually a serious proposition. In the first place the

opening of the road for traffic depends on the plow's performance. If derailed, traffic may be held up and the track department may be powerless to help without the plow. Again, in snowy weather, re-railing any car is not easy. The re-railing frogs must be spiked to prevent slipping and snow must be brushed away at every move to see what is next to be done. Tools are easily lost in snow and slippery rails add to the trouble. The Russell plow sets close to the rail. It is very heavy in front and hard to get under or to see under unless one can look through the "peek" doors at the sides of the front truck. The wings are close to the rail and may be jammed or knocked loose when the plow is derailed. In fact, great care must be used when backing a Russell plow around a wye or over switches on curves to be sure that the heels of the closed wings do not strike guard rails, crossing plank or other objects outside the rails. The modern Russell plow is a big car. It is heavy and hard to re-rail. On the other hand, it is very strong, and will stand a lot of hard use without serious harm, if properly handled.

The Russell plow is made for single-track and for double-track and in various sizes and styles, with and without compressed air for wings and flanges.

The single track plow is made to throw snow each way from the center of the track. Right and left-hand double-track plows are also made, which throw to one side only. The power bar of the Russell plow and of all other first-class push plows has a side play of a few inches at the rear end to allow for free movement around curves, the amount depending on length of car and sharpness of curve. Wood alcohol for freeing window and port hole glass from frost should always be carried on a snow plow as well as flags, torpedoes, coal, bell cord,

brooms, snow shovels, picks, axes, bars, spike mauls, track gage and rail fastenings, lanterns, wicks and matches. It is a continual problem to keep the necessary articles in a snowplow. It is curious that snowplow tools are generally looked upon, even by trackmen, as common property, and men who would not think of taking a tool from a section car house will get articles out of a plow and neglect to return them, especially during the off season. The surest way of keeping snowplow tools is to make one man responsible for them and have them removed to the car house at the end of the season. Although push plows may be run over the road in times of heavy storms in front of passenger trains, while all other trains are tied up, there is still danger, if the storm is severe or if a plow should meet with an accident, of tying up the road. The very surest aid to a train is to have a plow attached to its locomotive.

Pilot Plows.—Pilot plows have been used on American railways for many years. These plows are of various designs and sizes and are used in different ways, depending on the snow expected and the depth of the drifts usually to be removed. Pilot plows are ordinarily made of sheet-iron over a frame of oak. Sometimes the plow is fastened in front of the locomotive pilot. It is often used to make special trips to keep the road or yards open for other engines and trains. But the best place for a pilot plow is close to the pony truck of the engine; and if pilot plows are to be used at all the surest way is to equip every engine with a plow by removing the pilot in autumn, putting the snowplow in its place and leaving it there until spring. A first-class pilot plow of this sort is shown in Figure 14.

The outside flanger is worked by a hand lever from

the engine cab. This hand lever is much better than the compressed air lever, for it is surer to the touch. The outside flanger is where it can most easily be reached for road repairs. Extra shoes are carried on the engine and may be bolted on in a few minutes. The dust doors

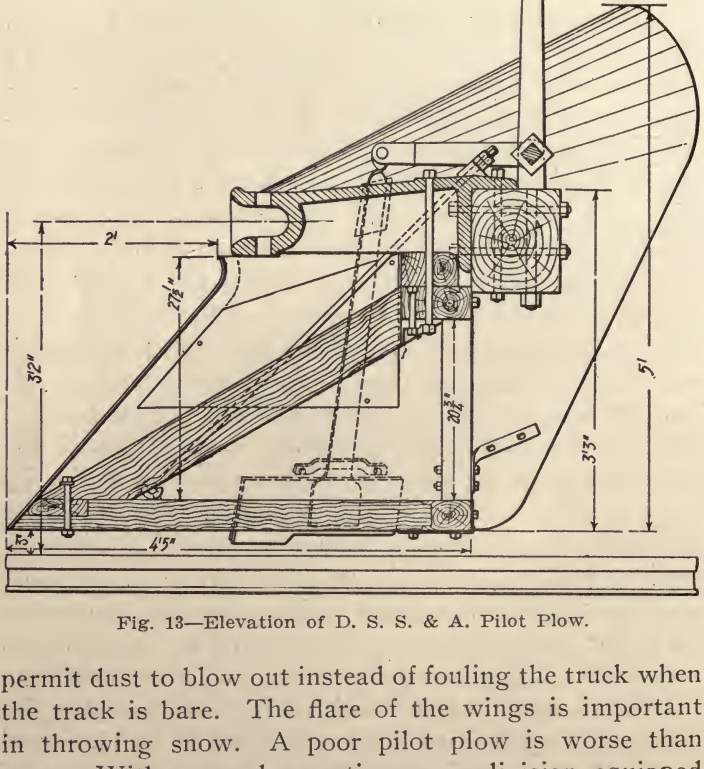


Fig. 13—Elevation of D. S. S. & A. Pilot Plow.

permit dust to blow out instead of fouling the truck when the track is bare. The flare of the wings is important in throwing snow. A poor pilot plow is worse than none. With every locomotive on a division equipped with a good pilot plow, only severe storms of late winter require the use of other snowplows except in ex-

ceptional cases and climates. The pilot plow shown in Fig. 13 will handle snow up to 3 or 4 ft. deep. Pro-

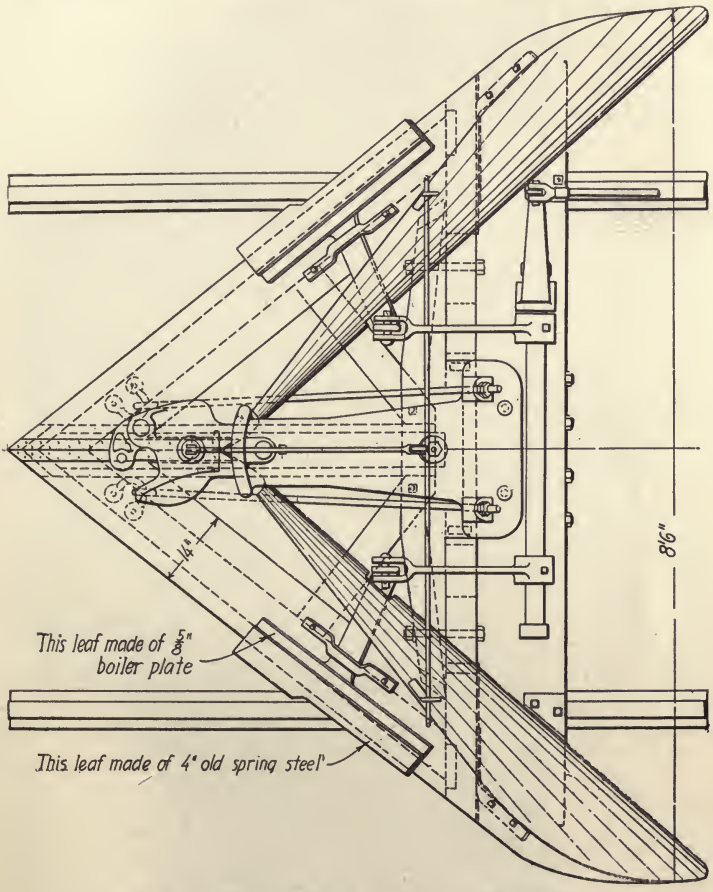


Fig. 14—Plan of D. S. S. & A. Pilot Plow.

vision must be made in all snowplows to guard against breakage in backing up. It is always possible to pro-

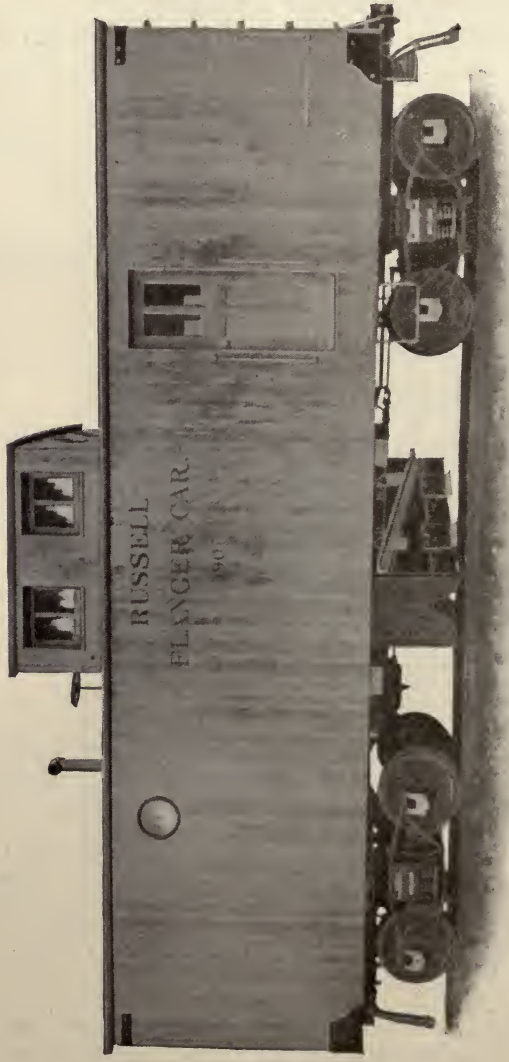


Fig. 15—Box Car Flanger.

vide reverse guards or shoes to keep snow from crowding under and breaking the wings or getting under the wheels.

Flangers.—Flangers also are of many makes and kinds. All are meant to clear snow from a space inside the rail so that the flanges of car wheels will have room to travel without being crowded with snow and ice. The usual

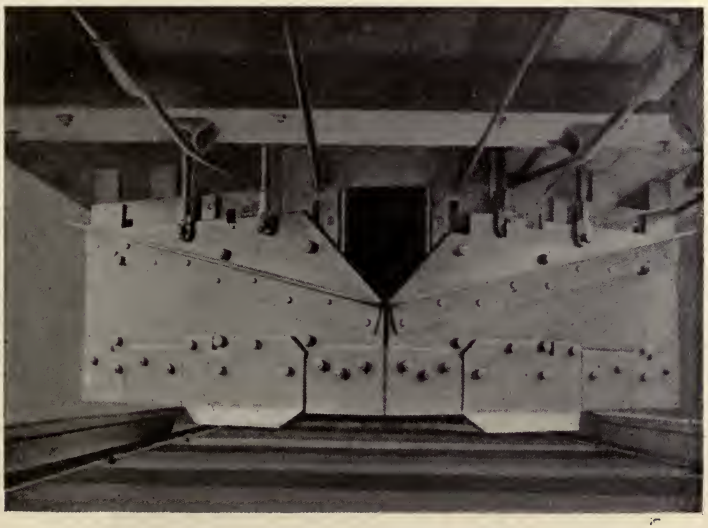


Fig. 16—View Underneath Single-Track Flanger.

width cleared by a flanger is 10 to 12 inches inside each rail. Flangers are steel knives or scrapers set at an angle across the track inside the rail, so that they can be raised and lowered by the operator to pass over crossings, cattle guards and switches. Some flangers are set just in front of the pony truck wheels of the engine, between the pilot and the front wheels, and fastened to the

truck. Others are fastened under the middle of a snowplow body, to clear the flanges as soon as the plow has passed, for the push plow will leave the space between the rails full of snow to the rail heads. As recent practice has proved the economy of putting all the machinery possible outside the engine drivers instead of under and between the wheels; so it has been shown to be best to

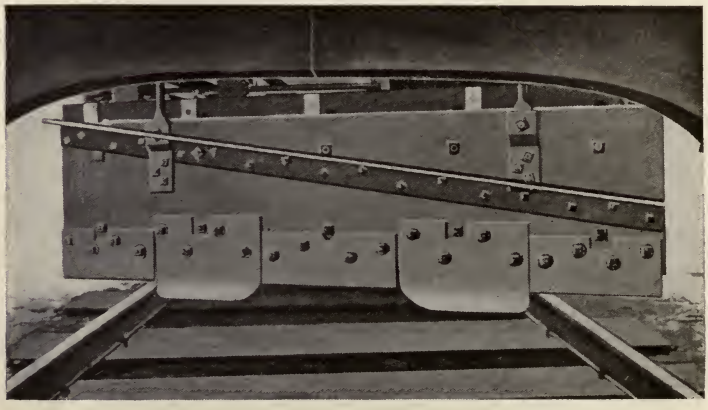


Fig. 17—View of Double-Track Flanger.

have flangers outside where they can most easily be reached and repaired. When carried on special beams or mold boards under plows or spreader cars, these beams should be so placed that the flangers are easy to get at to repair. Ice cutters made of tee rails with deep notched teeth like a reaper blade are sometimes used on flanger beams to cut high snow and ice from the center of the track.

Rotary Snow Plows.—The rotary snowplow is made of a covered car containing engine and boilers, with a long shaft, on the front end of which is a wheel with spokes

carrying fans, the whole wheel working inside a steel hood furnished with chutes for throwing the snow. (See Figure 18. The wheel of the rotary plow has hollow scoops of steel plate, funnel shaped and arranged on the spokes. Two knife-edged cutters are linked together between each two funnels. The hood of the rotary is square in front with a cutting edge only a few inches

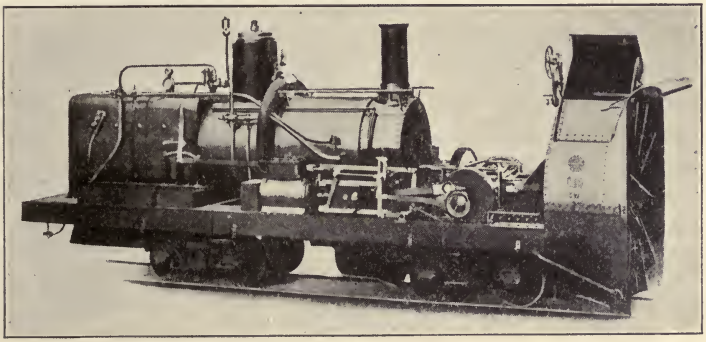


Fig. 18—Rotary Snow Plow with Housing Removed.

above the rail. The center of the wheel extends beyond the hood, but the rim is 3 or 4 inches inside. The wheel turns about 200 times a minute and when it is pushed into the snow the knives cut the snow, which is then thrown by the funnel-shaped plates as the wheel revolves, to an opening or chute in the hood. This opening can be changed by an adjustable cover so as to throw snow to the right or left, according to the direction of the wind, or to the place desired by the operator of the plow. The top of the hood is curved down to keep the snow from flying up, so the operator can see ahead from the upper side window. Some rotary plows have ice cutters in front of the front wheels of the lead truck and

flangers behind the trailing wheels. The operator who runs the plow, also runs the flanger and ice cutter by air; or, if the air fails, he can run them by steam. In very heavy drifts, say 12 to 16 ft. high, a rotary plow will go only 2 to 3 miles an hour; while in 2 to 3 ft. of snow it will go 12 to 15 miles an hour, the speed depending on the amount of snow handled. The chute throws a stream of snow about 4 ft. in diameter and it will throw snow of medium weight 100 to 150 ft., and is powerful enough to cut anything but solid ice.

A rotary-plow operator must be careful to handle snow so as not to injure property or persons. Hard lumps of snow or ice, or pieces of coal sometimes go through the chute with great force. Almost anything found in a snow drift will go through the wheel and and chute, and it is dangerous to stand anywhere near a rotary on the throwing side.

The Snow Crab.—A useful machine to run over a track before using a rotary plow is the snow crab. This is a device for pulling hard snow from the sides of narrowing cuts through drifts, to the center of the track (See Figure 18), where the rotary plow can reach and throw it clear of the right-of-way. Imagine a plow shaped like the letter "V" but with the two sides hinged one-third of the way back from the nose, while the nose is left off, the two sides being loose at that point from each other. The open edges are shod with steel cutting-plates and the device, framed at the end of a car, is pulled behind the car, the wings being opened to cut the snow as wide as needed on each side, and to guide it into the middle of the track behind the car for the following rotary to pick up. A variety of the snow crab machine has a wing extension at the nose end which guides the snow from the

center on across the track if necessary, so that snow removed from the right hand side may be left on the left hand side of the track. The rotary plow and snow crab

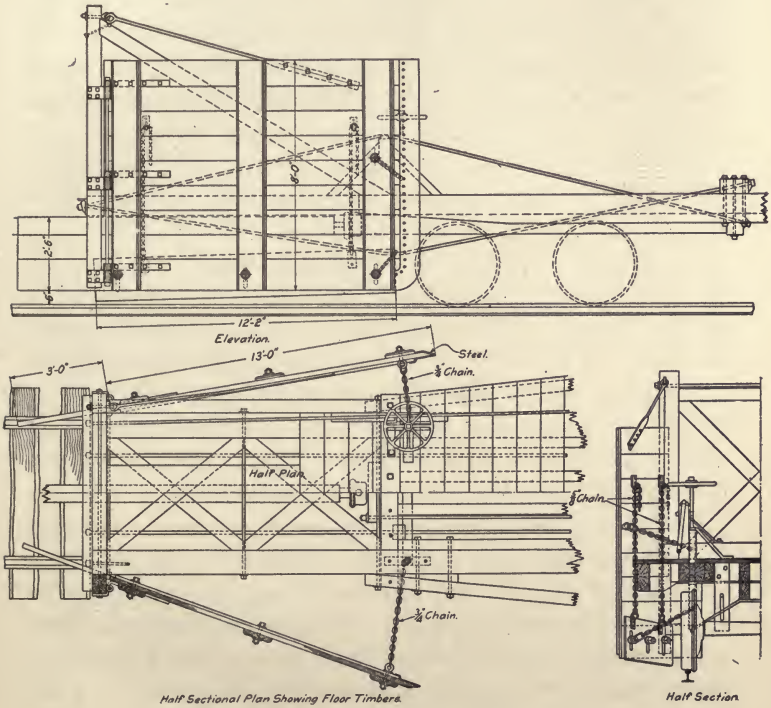


Fig. 19—Plan and Elevation of Snow Crab.

may be used economically to clear snow from yard tracks as well as on the line.

Clam Shell and Locomotive Crane.—Snow may be handled from between tracks with a special snow clam shell and a locomotive crane. The long boom of the crane will reach over three or four tracks and will put

snow far in the clear in yards where it cannot be easily disposed of in any other way. The bucket can easily be made in any shop, the gear of the ordinary clam shell being used. The ridges of snow left between tracks can often be handled in no other way except by clam shell and crane or by road train and extra gang. The clam shell makes a very clean job of snow handling, as it drops open and closes tight.

Spreader.—If two or more yard tracks can be cleared of cars at one time, snow may be quickly "spread" from one track to the next, until the entire yard is clear.

A spreader is a long wing hinged to a flat car or box car and well braced to stand the strain of pushing snow off the tracks. Ballast spreaders may be used for snow handling. The Jordan spreader is used by some railway companies and is especially good either for ballast or snow. When snow is heavy two spreaders are sometimes used, a short one ahead to clear one track and a long one following to clear two tracks at the same time.

In late winter hard, icy piles of snow are sometimes formed by continued spreading of snow to a certain line beyond the outside yard tracks. These piles or ridges of snow may be moved back by a ditching machine. The dipper should first be taken to the shops and the outside plate and teeth taken off, and a ⅜-in. steel plate, as long as possible, riveted on in its place to increase the shovel's capacity. The plate can be as long as the spud will allow. The ditcher is used on a flat car and will throw snow back 13 ft. It is slow and sloppy, but will move icy ridges that nothing else but pick and shovel will handle, and will do the work of 50 men when properly equipped and manned.

A most effective and economical device for clearing

tracks of snow and ice is a system of steam pipes hung from the pilot beam of a locomotive, shown in Figures 20 and 21.

This device is especially designed for use in yards and on tracks within the limits of switch leads and interlockers. The pipe reductions are so made as to obtain the proper force in the steam jets and the jets must be placed as near the rail as possible to be most effective. The pipes must also be at the proper angle and so spaced as to give the best results. This appliance is especially valuable at night when it is difficult for section men to see and work effectively among switches in yards. With well drained switch leads, no difficulty should be experienced in thus clearing tracks of snow and ice except in extremely cold weather.

Moderate snow falls may be handled at a speed of four to six miles per hour. Ice must be handled at very slow speed. If the steam rises so as to obscure the tracks, the engineman must shut off steam after clearing a switch lead or a certain short length of track, till a view is obtained of the next switch or short section to be cleared, when it may again be turned on for a few minutes. After a day's practice any engineman will become so well accustomed to this method of switch cleaning that he can with this appliance do the work of a large gang of laborers at a very small fraction of the total of their wages.

It should be borne in mind, however, that any device which melts the snow and ice in tracks is impracticable in extremely low temperatures, because the water will freeze before it can run off, even with good drainage. When snow is banked upon each side of the track, the best of drainage is ineffective in severe freezing weather.

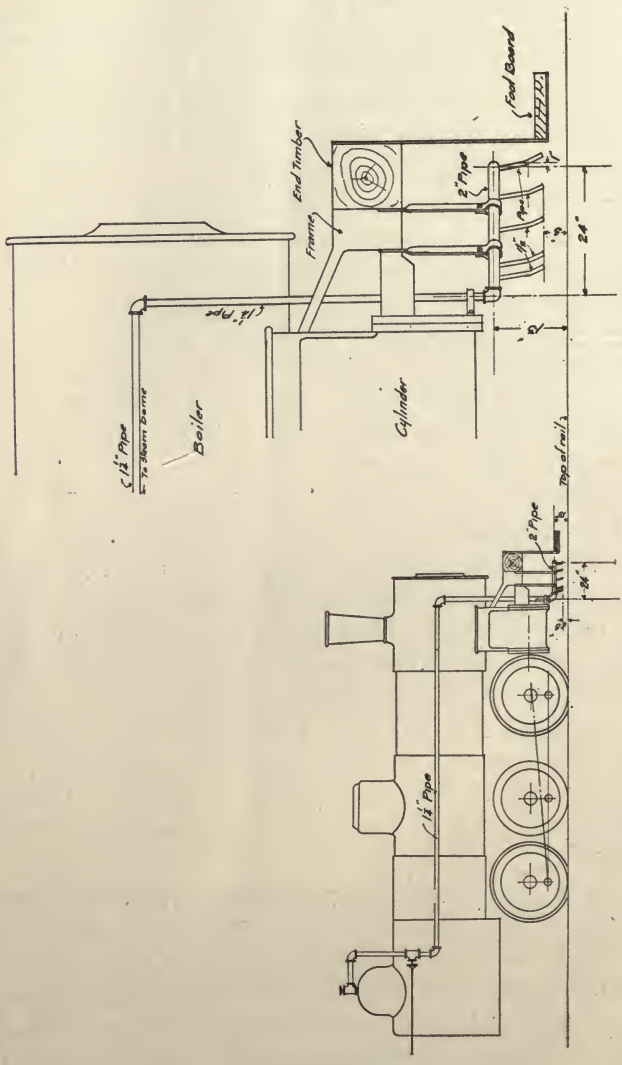


Fig. 20—Elevation of Steam Blower for Cleaning Out Snow and Ice.

Cleaning Up Behind Plow.—Snow and ice cannot all be handled mechanically. After plowing, the snow left in the middle of the track must be shoveled by hand,

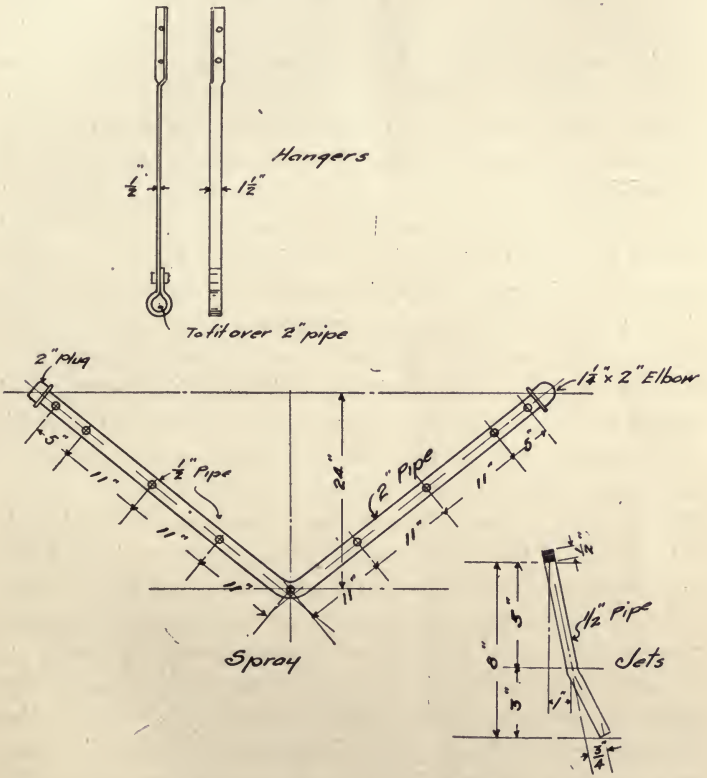


Fig. 21—Details of Steam Blower for Cleaning Out Snow and Ice.

especially in switch leads, on highway crossings, railway crossings, through interlockers, and around cars snowed in on side tracks.

The trackman must be very careful to keep snow and

ice cleared from switch points. When snow blows, it packs hard with the movement of switch rails between stock rail and switch points. Continuous work with pick, shovel, spud and broom is frequently necessary to keep switches in shape for traffic in winter. Drains must be made through snow banks to carry away water from melting snow before it can freeze in the track. After a switch has been cleared of snow it should be thrown to make sure it can be operated. Ground switch stands or stands with the working parts close to the ground are unsuitable for snowy localities. Section foremen should know of proposed movements of snow plows, so they may do their part of snow removal as soon as possible after a plow has started over their tracks. It is a good plan to have enough trackmen with a snowplow to help in handling it, to shovel it clear, if stuck in a drift, and to work the wings in case compressed air is not used. Plows often get off the track. Trackmen are needed to help in rerailing plows and their engines, and to repair track which is out of commission on account of derailments. For the best results local trackmen, well acquainted with the country, the climate and the tracks are needed. Strong, long-handled snow shovels should be provided in plenty. Snow shoveling needs planning, though it looks easy. An experienced snow shoveler cuts the snow into cubes with his shovel, and lands the snow with one throw where it need not be moved again, and where it will not be in the way of other snow handled later, unless there is so much snow or so little room that double handling is known to be unavoidable.

With the best of management, a great deal of snow shoveled in large yards must be handled twice, and in a very severe winter some of it is handled oftener. The

best way is to make plans for proper handling of the average amount of snow and ice to be expected during a winter season and to haul away the first heavy snow rather than the last.

Snow shovelers should not be allowed to work too close together in heavy drifts but should be spaced and kept spaced according to the work to be done. One cleanup man to a certain number of shovelers is needed around buildings to make a clean job. Foremen should not neglect icicles which form on eaves of railway buildings and which endanger all who pass under them. It is well to pick out more than one place after a storm where snow shoveling can be done in a yard, so that in case of any interruption, such as switching, the gang can be shifted from one place to another and kept at work.

Handling a Push Plow.—Handling snow with a push plow requires judgment. There must be suitable power behind the plow, and proper understanding with train dispatchers. Reports of all obstacles met, of weather conditions, of conditions of main tracks, passing and other tracks, should be sent promptly and worded clearly. It is dangerous to rush a plow into a snow drift without knowing what is under the snow, unless there is no chance of ice. It is best to shovel the track rails clear to a face of about two feet of snow before sending the plow into it. This takes some little time but it saves wrecks and derailments and injury to equipment, if not loss of life. A certain knowledge of clearances will save time in plowing and the time of track gangs who shovel snow where the snow plow wings cannot be opened. There are driveways, cleaned switch leads, and hand-shoveled side tracks on nearly every trip, which may or may not be filled with snow according to the way in which snow plow wings

are handled. A good operator on a snow plow is a valuable labor saver if he knows his road and uses his knowledge of clearances and snow conditions. The dispatcher may make or mar a snow plow trip. He should know the conditions as well as the snow plow operator, and he should be allowed to give the plow the preference necessary to clear the tracks for traffic. It is usually necessary to sacrifice some of the time of regular trains in favor of the snowplow. It must be borne in mind that the plow is being run so that trains may make schedule time after the plow has passed over the line. If the tracks need plowing at all, they should be plowed quickly and well, and this can only be done by giving the plow the preference due a special train.

Rerailing frogs that can be held to the rail are handy to have on a snow plow. They will soon pay for their cost in case of derailments on snowy tracks. The time lost in scraping away snow and spiking rerailing frogs to the ties is time wasted, not only for those with the plow but for all who are waiting for it to clear the tracks.

Clearing Yards.—In yards, the work of clearing sidings on which are cars that have been snowed in, is necessarily slow. It is much better to take out one car at a time safely than to attempt to pull out a train and get off the track. In deep snow, the switch engine may not be able to reach the first car. When the engine has been forced as close as possible, the snow between the engine and the car is shoveled clear, so that the coupling can be made to four or five cars, or as many as can be moved back and forth a few feet at a time until the snow falls off the wheels and trucks to some extent. These cars are then pulled out of the siding and the next few cars are gone after, given a shaking and pulled free, and so on.

Empty cars often have to be handled one at a time. They are so light that they easily jump the track and must be carefully handled. After a "snowed in" track is freed of cars, it is full of snow between the rails and should be plowed and flanged out.

Preparing the Snow Plow.—Before a plow or flanger is taken out, it should be thoroughly cleared of snow, inspected and tried. Complaints that a beam flanger, built on a flat car, and air operated, would not lower properly, have been caused on account of tools which had been left under the beam in the snow. All snow plow parts should be cleared of snow before starting on any trip.

A Russell plow with air worked wings needs no track men when everything goes well, but a wheel off the track is a serious matter, for the forward truck is so boxed in with the plow body that it is hard to get to it. Help is also needed when the plow sticks in drifts or must wait till a face is shoveled in the snow at cut ends. The rotary plow is a powerful machine, but a few men should be carried with it to assist in case anything goes wrong; and this applies to any other snow fighting machine.

Extra Men.—Most northern railways have less trackmen, and pay less for a day's work in winter than during other seasons of the year. The hardest snow storms come when there is the least number of men on hand. Many extra men must be hired for the work. These men know little of what is expected of them and the company loses money because it is hard for foremen to oversee all the work that must be done. It costs a company very little extra money to give the best regular men of a gang the summer wage for acting as assistant foremen over small squads of green hands hired to help handle snow and ice during winter storms, and the money is so well

spent that few railway officers will refuse such an arrangement when explained to them, if authority can be obtained.

It is worth while for a foreman to spend some time and thought in locating the homes of men who want work in winter and in finding out how to get them on the job quickly. It is to the company's interest to hold men who can hire laborers on short notice, and who can pick out good men from the unemployed. Any scheme for keeping men within easy and quick reach in case of emergency should be encouraged. A good foreman will have the names and addresses of extra men and will have his regular men bunched where he can get them in the shortest time possible at any time of day or night, on Sundays or holidays. All trackmen know that wrecks and storms have a way of occurring at week ends and on holidays, when the least watching is done and when many regular employes are on leave or absent from duty. The foreman who can round up his men quickest is the most valuable to his company, and particular attention should be paid to this duty. The track foreman, like the captain of a fire department, is expected to be always ready for duty. To be properly ready he must know how to get men and tools in service quickly and if he wants promotion, he cannot do better than to think out for himself how best to do this. It is not easy always to get men to work in bad storms, but some foremen do it where others fail. Tact and care are necessary and well worth while. A foreman who has a following of laborers who will do a fair day's work is usually successful. The foreman is the go-between of capital and of labor. He must be honest and shrewd to succeed.

Comfort of Trackmen.—In winter weather the bodily

comfort of men at work out of doors is an important consideration. Steaming hot tea or coffee, made on the snow plow stove, has saved the day in many a snow fight. Arrangements for meals should never be lost sight of, and cars should be placed at night where the men's rest will not be broken.

Signals.—The most important thing in plowing snow is to have a perfect system of signaling from plow to locomotive. Everything depends on the signals. No experienced snow fighter will start until he has actually run through his list of signals with the train and engine crews, and tried them out.

Safety.—In case of accident the safety of the snow plow crew depends largely on the way in which tools, stove, fuel and all loose articles are handled in the plow. All these things should be fastened in some way, so they cannot fall about if a plow turns over. Tool and coal boxes should be made very strong and kept closed and latched or locked. The larger tools can be set in locking racks. The jacks and rerailing frogs can be set in heavy iron-barred, built-in boxes. Fuel boxes should preferably be built into the car, and be strong enough to hold together if tipped over when full or partly filled with fuel. The stove should be fastened in place as strongly as possible.

All these precautions will do little good unless someone makes it his particular business to see that tools and fuel are in their proper places at all times and that racks and boxes are properly closed.

Every trackman knows of ways to get his work done best and easiest on his own particular job. His acquaintance with people and country, with the equipment and the tools at hand, enables him to get more done in a day than a stranger. There is always room for improvement

in the ways of doing work. Every improvement is money and time and work saved. Every trackman will be worth more to his company if he studies these things and improves on his ways of caring for track.

CHAPTER VIII.

SPRING FLOODS.

High water, caused by the sudden melting of snow, which frequently goes off with heavy rains, is a cause of anxiety to trackmen of northern railways. Serious trouble often results from washouts and landslides indirectly due to various causes. If the ground is frozen hard, rain or melting snow must all run off instead of partially soaking into the ground. A warm rain takes off the snow very suddenly, and a water shed, which ordinarily causes no trouble, may send a deluge of water in a few hours to culverts and bridges which are too small to take care of it.

Inspection.—Log jams, ice gorges, floating stumps, old ties and other refuse must be watched. Beaver dams, crayfish holes, muskrat holes, changes of channels, the breaking of dykes and opening of spillways must be reckoned with. Often these troubles start some distance away from the railway company's property. Without notice a log jam or ice gorge may be dynamited, or the water may be released from behind a dam out of sight of the railway, in order to save other property. Some change of channel or newly dredged ditch may throw much more water to a railway waterway than has ever gone through it before. Landslides may occur on account of the frost going out of slopes while heavy rains are falling.

At this time of year, the tracks are not only on high shims in many spots, but these shims must be changed daily to keep the tracks in the best condition. Broken

rails must be watched for most diligently under such conditions. The closest and most thorough track patrol is necessary to prevent accidents to trains. A washout or landslide is serious enough when it obstructs a track, and ties up traffic. It is doubly regrettable if cars or locomotives are derailed in consequence. The best of track walkers and plenty of them, the closest attention to shims and track, promptness in answering emergency calls, the provision of emergency materials such as bridge timber and piling on cars, sand bags, riprap stone, dynamite with electric batteries and long wires for firing the charges, pike poles and ice spuds, should all be thought of and arranged for before the break up of winter.

The closest scrutiny of all waterways is needed when streams and lakes are rising, and especially when the currents of water are rapid, or when water backs up against railway banks. A very small leak may cause a bank to soften from beneath while it looks perfectly safe on top. The track may be undermined from some seepage along a pipe or at the side of a box culvert or behind the backing of a bridge abutment, before any settlement shows in the track; and a train may take the whole structure down with it into the water without a moment's warning. It is well for trackmen to examine most carefully the action of water above and below the track, to look for any water seeping through the banks or outside of culvert walls, and to report all suspicious looking cases by telegraph. Even if a bridge foreman is put to unnecessary trouble a few times and assisted in preventing only one washout through such care on the part of the trackmen, much has been gained.

Conditions Adjacent to Right-of-Way.—Knowing what

is going on in the community about him is part of a track foreman's duty. He should make it a point to know about all enterprises of farmers and others which might affect the waterways of the railway company. Dredging and ditching, sewer building, dam construction, and the changing of water channels should be promptly reported.

Trenches through snow banks and at the outlets of ditches in cuts are needed for drainage and should be dug early. All places where ditching seems needed should be reported so they may be attended to before the next winter. High water marks should be made at all waterways as a matter of record.

Washouts.—If a washout occurs, the quickest way to get the track in service again is usually to crib it up on ties or bridge timber provided the water subsides quickly. If it stays high, filling with stone or sand bags may be best. The stone fill is permanent, while the bags of sand are only temporary, and the timber cribs must be renewed later. Sand bags should be filled only three-quarters full, so as to lie flat against each other. The proper way to fasten sand bags after filling is to sew the top end with sail needle and twine. Gunny sacks are larger and no more expensive than cement sacks, and unless the sand is very fine, the gunny sack is the better proposition.

When water, having no outlet, gets higher on one side of a railway bank than on the opposite side, there is danger, for water always seeks its own level. If it overflows the track the bank will probably be cut out. In such cases, ridges of filling along the top of the bank outside the rail, may save the line; or sand bags laid end to end in a row on the shoulder of the bank may be of service to the trackmen. Good use should be

made of the telegraph in such cases, especially if materials to mend a washout are not at hand. Authority can usually be had to buy bags or other materials locally if time can thus be saved. The most important thing to do is to act quickly whenever a washout threatens. When reporting conditions, go into details. If the man who must help you must be told by telegram, give him enough correct news to enable him to bring with him just what is needed. There is no more expensive and annoying predicament than a hurry call on a vague report of trouble. The trackman has usually a very good idea of what is needed. And he should not fail to put that in the telegram and insist that it be sent as worded. The trackman is the company's representative on the section. On him the company depends for safety. He must realize this and act accordingly to get results.

CHAPTER IX.

STORING ICE.

Railway companies whose lines reach into cold climates usually store their own ice for all purposes, including the icing of refrigerator cars, passenger coaches, dining cars, road trains, hotels at meal stations, offices and depots. Some companies furnish ice to section houses.

Cost of Putting up Ice.—The expenses involved are the cost of and taxes on land, on ice houses, ice chutes, equipment and tools for cutting, storing and delivering ice; road-train service, cars, side tracks, telegraph stations and operators in service for ice harvest only, the labor for the ice harvest and the supervision. There must also be debited a generous allowance for waste of ice, between ice field and loading chute, between car and house, including ice broken in transporting, in unloading and in packing in the storage house; also waste by melting in storage, in removal from house, in breaking for use, in transporting to outlying stations, and in melting at these stations before being put to the intended use. Probably little more than half the ice cut reaches the consumer in railway service. This percentage seems excessive, but is nevertheless a fair average result.

The alternative is the purchase of ice from contractors who take better precaution against shrinkage or who manufacture ice as it is wanted. The purchase must include the contractor's profit and delivery expenses. Harvesting and handling by the railway company is cheaper, even with all the losses, under ordinary conditions in the north.

Ice Storage.—The storage of ice is usually left to track-department officers using their own men in extra gangs, or contractors' labor and equipment. Some roads hire contractors to work under the roadmasters, payment being made by the number of cords of ice stored in the companies' houses, the railway company furnishing the supervision, the ice in the field, the boarding trains equipped, the cars and engines and crews, and switching service at storage houses, and the houses and machinery for storing. Other roads do the whole work with the track department forces. Extra-gang labor is usually most plentiful in the latter part of the winter, in February and March when the ice is thickest.

Location of Ice Houses.—Whenever possible, ice houses are located on the shores of the lakes or ponds from which ice is taken. Inclined runways of wood extend from the house doors to the water, and the best power available is used to hoist the ice from the water into the store house, from which it is removed as needed to cars on the opposite side of the house.

Such an ideal arrangement is by no means common. Frequently the company's best ice supply is a lake or dammed stream far off the main line and at a distance from the ice houses at division headquarters. The ice, especially drinking-water ice, should be pure and from a spring-fed source. The snow must be kept scraped off the ice while it is forming. A heavy snow may otherwise sink the clear ice, forming a layer of "snow ice," or a sudden warm spell may melt the snow, flood the ice and cause the formation of rough, opaque layers with many air bubbles.

Time to Start Cutting.—The best of judgment must be used as to the date of starting the ice harvest. The ice

must be thick enough for packing to start with, and not too thick at the time of completing the cut. Where enough confidence can be put in the climate, the harvest is not begun till ice is 10 in. thick. It should not be more than 20 in. thick at the last. Ice is cut usually in cakes 22 by 44 in.

Ice houses are cleaned, and hay, straw or sawdust provided for packing at the beginning of the harvest. Road trains, cooks, dishes, provisions and bedding, stores and fuel must be supplied. Tracks, engines, crews, watchmen, telegraph operators, tallymen, foremen, laborers, horses for marking machines, hoisting machinery, chutes, car doors, and tools are to be arranged for. Strikes among workmen in the midst of ice harvest must often be reckoned with. If flat cars are used, stakes and planks for siding must be provided. Traffic arrangements for ice trains must be made. The further the ice field is from headquarters, the greater are the difficulties for the roadmaster. The trackmen are frequently called on to do all or part of the work of the ice harvest, especially in cases of emergency.

Conserving the Ice Supply.—The secret of conserving the ice supply is to watch and stop the leaks. Many railway eating houses have cooling rooms too large, with ceilings too high, and with refrigerators near stoves. Doors are often not properly equipped with springs and locks. Ice houses often are poorly insulated. Anyone can go in and help himself. There is no limit to the amount of ice taken by janitors, train crews and office boys who leave doors open and ice uncovered. Large ice houses should be in charge of attendants. Signed orders, like fuel orders, should be required and ice should be delivered by weights mentioned in these orders. Road

trains should have certain fixed, well built and properly located ice boxes, and should be allowed certain amounts of ice per day or week.

Ice should not be sent from station to station by train unprotected, when it can be bought locally. The loss in transportation is too great for economy. The icing of refrigerator cars may be done economically or with great waste. Speed in handling from house to car is imperative for economy. Trackmen can frequently make large savings in the use of ice by watching these points and reporting on them to the proper authorities, especially where ice is rehandled at way stations.

CHAPTER X.

ORGANIZATION.

We measure labor by the work one man can do in one day, under present conditions of civilization, government, customs and conveniences. But the work one man could do without these helps would be much less. To make much progress man must depend on his fellow man very largely. The laborer must be fed, clothed and housed. He must have tools, equipment and materials. Many men of many trades must work to supply these needs, and they in turn must be similarly supplied by others. The great buildings and cities, ships and waterways, roads and railways of the world are all the results of the work of many men.

First Requisite.—The first thing in organization is the getting together of a number of men who form the plan of action. Their first need is money and credit. A number of men may become stockholders, each furnishing a certain part of the money needed. There must be officers of this company to represent the stockholders. These officers appoint men skilled in the details of construction and of organization for the building to be done. The building or construction is further organized by dividing the work into departments, with a head of department and subordinate officers and foremen. These men employ skilled and unskilled laborers, purchase and furnish tools, materials, equipment, and money for wages. Each man must know his duties, his place in the organization, the best and quickest and cheapest way of doing what is expected of him. He must be trained and skilled in some

certain work, to be done in harmony and in understanding with others. For an untrained army is little better than a mob, though the men may be loyal, willing and intelligent. There must be understanding, for no one can do his best in the dark. Most men will do right if they can be brought to think right. The exceptions are criminals. There must be harmony in plan, in action and in thought, or the object sought will not be best attained.

Peculiarities of Railway Organization.—Railway organizations face difficulties peculiar to public service and to lines of transport. Long distances, legislation and climate must be taken into consideration. The greatest care must be exercised to make the organization as near perfect as is possible, to promote an understanding between men who seldom or never see each other; to promote safety and get the best work from men in different departments working on different details, but all with one object. It is not easy to keep before each man this one object; to make a section man realize that the company's life depends on getting freight and passengers safely and economically delivered, or to make freight or transportation employes realize that a section gang's place is on the track; or to teach each man that he must recognize the importance of the duties of all his fellow workmen of other departments. For a thorough understanding, he must know what their work is. The very best road to mutual understanding is personal contact. Organization is not merely being together or being put together. It depends most largely on getting together and keeping together in understanding and in sympathy if not in person.

The Foundation.—Although organization starts from the top, railway officers start from the bottom. They en-

ter railway service as section laborers, as freight handlers, as office boys, as engine wipers, as car cleaners. As they rise to more important positions, they learn to do many things; they learn how to teach other men to do them, and how to teach these men to teach others. There is one best way to do everything, and these methods must be studied, practiced and taught. Men learn not only from their superiors but from the men who work under them.

There is no reason why a man in a minor position may not get to the top of his organization. There is nothing impossible about a section man becoming a railway officer if he wants to work hard enough and will do it. Every man has the chance. His success or failure depends on himself. But he must be a worker in more ways than one. Not the man who works hardest, but the man who makes his work count for the most, the man who does the right thing in the right place and at the right time, is the winner. A man must not only strive to learn continually, but he must teach others to do things for him; otherwise he cannot get far beyond the results of his own day's labor. And he must not only teach others, but he must learn how to so manage men as to get them to do more for him than they could or would do for other men. Leaders of men, men of self reliance, resourceful men, men who can make others accomplish much, are always in demand, in all kinds of business, in peace and in war.

Executive Ability.—This art of leading men is called executive ability. Few men have executive ability because most men do not take the trouble to learn it. Out of 100 section foremen who can handle gangs of 5 laborers each, probably only 20 can properly handle gangs of 10 men. With good assistant foremen to help them, possibly 3 out of these 20 foremen are able to handle gangs

of 40 to 50 men. Why? Because, though they know how to do the work themselves, most foremen cannot so organize large gangs, and so supervise them, as to get the men to do the work correctly and faithfully. It is natural that men should work much better for a foreman who knows his business than for one who does not. This means that the successful foreman must be an organizer, not necessarily the strongest foreman, but the most far seeing. He must plan his work ahead. He must have it mapped out in his mind before he starts. He must know how many men to put at each class of work to keep the entire job going smoothly and he must see that each man does his part, that materials and tools and equipment are furnished, that boarding facilities are good, that disputes are justly settled. He is the judge of all that goes on under his orders. Now, any man can learn these things if he will learn. Such men are always in demand. Such men make railway officers and they make the best officers.

Suggestions for Those Desiring Advancement.—A few hints of what not to do may not be out of place here, and may possibly help trackmen who have an interest in getting on in the railway world, of holding better positions and taking on larger responsibilities. If only one reader is helped the author will feel well repaid for his labor.

Don't lose your temper. You never really gain anything but invariably lose by impatience, peevishness and the showing of temper. You must govern yourself before you can govern others. A great philosopher has truly said, "Who then is free? The wise man who can govern himself." Loud talking and profanity are signs of the undesirable person. Any month-old puppy learns in a few hours to disobey a person who yells at him unneces-

sarily. Many great men have reputations for keeping silent at the right time, of attending strictly to their own affairs, of being polite to everyone, of speaking quietly when they do talk.

Don't correct any man in the presence of others. It hurts his pride and makes him resentful. You need friends and you need to avoid making enemies. Before giving an order, be sure you are right. When given, be sure the order is obeyed without fail. Have no favorites in business. Be just to all men, for on justice is founded every good thing, all that is right and fair and proper among men, the world over. Study your work. Talk it over with your boss. He will be glad to get your ideas. He can't know that you have any, if you hide them. Talk it over with your men. Their ideas may be better even than your own. Never do all the talking. The art of conversation is to keep others talking. Don't make conversation in business. You can not learn unless you listen. To be a good listener is better than to be a good talker. A man who knows or thinks he knows it all, is to be pitied, for no one can teach him. When a man ceases to learn, his brain is useless, he cannot progress.

Men are more easy to lead than to drive. Leadership is easiest without a show of force. If you ask a man if he doesn't think a certain way of doing is best, if you can get him to suggest your way of doing a thing, if you can make him think you are doing it at his suggestion instead of insisting on having him do it your way, he will be more willing to co-operate. Such leadership is diplomacy. Diplomats are few, their salaries are high and their services are desirable. Diplomacy is needed by every trackman. A good foreman studies his men as well as his work. He cannot do all his work with his own

willing hands. Therefore he must make other hands willing. No two men are exactly alike. Each man is a problem. All must be tried out. All must be given responsibility. Some have one limit, some another. Some men grow rapidly in capability when given the chance to show their worth. The study of men is even more important than the study of the work. This may all seem hard, but it is easy. It comes naturally with practice. Any man can increase his wages again and again by such study. Certainly there are difficulties. Laugh at them. Men are made by difficulties. They are made to overcome trouble. The further up one goes, the less trouble he has. He gets used to trouble. He learns to have confidence in himself and he learns to scorn trouble and worry. Don't fail to learn, to inquire, to ask questions, to remember what you hear. The time may come when information which you thought never would do you any good, may be of value.

Don't fail to learn the work of the man above you. If you don't know his work you never can expect to have his job, or one like it. Be ready for the vacancy. Keep it in mind. Don't let a chance slip by. Never mind if the work is not just to your liking. Jump at the chance, for chances will not come your way if you don't take them. Be always ready, always studying, always looking for promotion. When you know you can do a thing, say so. Keep your eyes open, your ears busy and your tongue under control. The man above you has his eye on you. He is looking for the best men. The others he doesn't think much about. Advancement is sure to come if you want it bad enough to force yourself to do your work better than other men.

Remember the company's dollar. The best man, from

highest to lowest, is the man who can and does make that dollar go the farthest. This rule has no exception. Be patient, for the world was not made in a day. You have much to learn; everyone has. You do not know it all; nobody does. Do the things that are worth while. Don't spend time on the things that are not worth while. Some worthy things are better than others. Choose the things that are best for you. Let alone the things that are not the best.

Don't waste time. It is the most valuable thing in your life. You may live to be 70 years old. If you are 25 now, you have 45 years to live. How will you spend your 45 years? Do you want to make the most of it? Then don't waste a minute. Wasted minutes never come back. They are gone forever. Your life is passing. Grasp each moment and make it count for good, for the best of the good. Don't trifle. Think these things out for yourself. Plan what you will do and how you will do it. Be methodical. Plan your days, your weeks, your months, your years. Don't waste time with men or books or thoughts that are not of value. Talk to men who can be of service to you. Read only that which will help you. Do only what is best and right and useful, and use your influence to get your men to do likewise. Plan your daily work and your life work. Map it all out ahead. Keep at it. Never be discouraged. If your plan does not work out, try another. You may have overlooked something. Try again. Do not try short cuts to success. Most of them are disastrous all the time. The remainder are disastrous most of the time. It is hard work that counts. It is determination that makes progress. It is the real worker who gets the best out of life.

The trackman has one great advantage over all or nearly

all other men. His work is hard, physical, out-of-door labor. It is the healthiest kind of work. Health is the best thing in life. The trackman has this wonderful start over the banker, the lawyer, the doctor, the dentist, the merchant. He is out of doors. He is tired every night. His appetite is good. His sleep is not disturbed by poor digestion. These are the men who make the best soldiers, the best railway officers, the best men everywhere. With the good health born of hard labor out of doors, the trackman has by far the best chance of success. Then study, learn, keep at it. With your teeth shut hard determine that you will learn, that you will rise. You cannot lose. The world is yours; only keep after it. Organize your men, your work, your own life. Make yourself a leader of men. It is all in your power, only organize.

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